

Chemical & Process Engineering

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Topics of the Month

Fertiliser conditioning

IN Britain the problem of producing compound fertilisers with lasting friability has receded with the development of granulation. In the United States, where granulation is still in early stages of development, the problem has steadily increased. The demand for compounds with higher and higher analyses intensifies manufacturers' difficulties, for there must be less and less room in each ton for the conditioning 'filler.' Indeed, the role of the filler has been sadly misinterpreted by fertiliser buyers. All too often it has been regarded as a means of dilution and greater profitability. While this may be true when excessive amounts of sand or other cheap minerals are used, it has been far from true when reasonable amounts of bulky organic materials have been incorporated. These materials undoubtedly minimised caking and setting and enabled compound fertilisers to be stored and later to be applied without serious physical handling problems.

Now, except where the granulation process has been introduced, the manufacturer must find a filler which is highly effective as a conditioner, despite the fact that only a little of it may be added to each ton. An entirely new research approach to the whole problem of conditioning is being made in the United States. It has been found that the tendency for NPK mixtures to set is greatly dependent upon their initial content of moisture; below 1.5% of moisture—a low figure unlikely to be achieved in practice without deliberate

drying—there is little tendency to cake even under pressure. This confirms the outlook of at least a few fertiliser chemists who have suspected that the principal merit of a granulation plant resides in its drying chambers. The particle size of the fertiliser mixture is also a major influence. The strength of cakes formed by pressure falls rapidly as the particle size of the mixed materials increases. Indeed, changes in favourable directions for moisture content and particle sizes can produce larger reductions in the caking tendency than the reductions obtainable by using 5% additions of established conditioners.

As for conditioners themselves, their relative effectiveness varies inversely with their apparent densities; in short, the bulkier they are the more likely it is that a small amount will exercise a large effect. The fact that they may be of organic origin is insignificant; it is simply a coincidence that many of the bulky materials available have, in fact, been organic wastes. Thus, diatomaceous earth (apparent density, 13 lb./cu.ft.) is superior to cocoa shell meal (25 apparent density). But the two most effective conditioners would seem to achieve their effects by chemical means. These are magnesium oxide (calcined magnesite) and urea. Remarkable reductions in caking have been obtained with 1% additions of the former and 2.5% additions of the latter. As both these materials themselves provide plant nutrients, urea being a particularly concentrated nitrogen supplier, it is possible to achieve excellent condition without reducing the nutrient values of mixed fertilisers.

Silver Jubilee of 'Food Manufacture'

THE June issue of our associate journal, *Food Manufacture*, its Silver Jubilee number, is a landmark in the history of specialised technical journalism. In it are published brief but concise *résumés* of the progress of representative sections of the food industry during the past 25 years and discussions of the problems facing it at the present time.

During the 25 years of its existence *Food Manufacture* has faithfully recorded the progress of the industry it serves, describing the multitudinous changes and improvements in its methods, the difficulties overcome and the many improvisations rendered necessary to solve its problems, both in war and peace.

Of the authors of the articles published in the June issue, there are some who contributed on their special subjects to the earliest issues of *Food Manufacture*. These experts have since been actively engaged in their particular branches of the food industry and are still so engaged.

This considerably enlarged issue is worthy of being preserved for reference purposes for years to come.

Fuel research report

AT this time of coal shortage, investigations into the more efficient use of fuel are of special importance. While, considered broadly, all studies carried out by the Fuel Research Board have that end in view, those which are directed particularly to the immediate saving of coal are yielding valuable results which are already being applied successfully in industry. Development work in hand at the Fuel Research Station, London, covers the chemical examination, carbonisation and gasification of coal, the production of oil and chemicals from coal, steam raising, gas turbines, atmospheric pollution and smoke abatement and other fuel problems. Details of research in some of these fields during 1946-49 were given on p. 82 of our February issue. A further report, 'Fuel Research, 1949-50' (H.M.S.O., 2s. 6d.), has recently been issued, and the lines on which this research has been continued are clearly indicated.

One example is that experiments have been continued on the gasification of fine low-grade coals and cokes in order to provide producer gas, water-gas and gas for the synthesis of oil, while applications of the fluidised-solids and suspension techniques have been studied. Investigations of the synthesis of oils from coal by the Fischer-Tropsch process and its modifications have also been carried on, and the construction of a pilot plant to produce 30 to 50 gal./day of product was started in the period under review. An investigation is also in progress on the combustion of coal to provide the energy for a gas turbine, and experimental work has been undertaken using vortex and straight-through combustion chambers designed at the Fuel Research Station.

Owing to the continuing sulphur shortage, methods for the removal of sulphur compounds from flue gases, particularly in relation to the gases emitted from electricity generating stations, that have been studied at the station can be expected to be of considerable value, and more recently attention has been directed to a process in which ammoniacal liquor is used and sulphur is recovered, mainly in the form of ammonium sulphate. The promising results obtained in a small pilot plant led to a decision to erect at the station a larger plant to deal with 25,000 cu.ft./hr. of flue gas. If the process is a success, technically and economically, there should be considerable scope for its employment in this country.

Canada's expanding oil industry

CANADA now has a large and growing oil industry which processes \$1,000,000 worth of crude oil every day and whose markets and total capacity, in spite of recent discoveries, are still about double the crude production in volume. However, owing to the large potentially productive regions in that country, it has been estimated that crude production may come to equal consumption within four or five years. The great future for the Canadian oil industry was emphasised at the recent annual dinner of the Institution of Chemical Engineers by Mr. John Rogers, the president of the Society of Chemical Industry and chairman of Imperial Chemical Industries Ltd., who referred in particular to the high status enjoyed by the chemical engineer in that country.

At present, however, the greatest shortage of trained manpower in the Canadian oil industry is probably in chemical engineering, caused largely by the rapid expansion over the last five years. Of the 7,500 students now in the engineering departments of the main Canadian universities, more than 600 are studying chemical engineering and nearly 220 of them are due to graduate this year. In particular, the University of Alberta has initiated a course in petroleum engineering, in which about 60 students are taking part.

Yet, in spite of the important developments in this industry, nearly 98% of the capital invested within the last five years originated in the North American continent, rather more than half of it coming from the United States. Here surely is a field in which British investments should be encouraged to a much greater degree.

Chemicals from the oxidation of hydrocarbons

PHENOL and acetone, two chemicals in big demand, are to be made by a new process involving the oxidation of hydrocarbons. One project employing the process is in Canada, where B.A.-Shawinigan Co. (formed jointly by British American Oil Co. and Shawinigan Chemicals Ltd.) are building a plant for the manufacture of phenol and acetone by the oxidation of cumene or isopropylbenzene. The other is in the United States, where the Hercules Powder Co. are to build a plant for making phenol, *p*-cresol and acetone by the oxidation of both cumene and terpene hydrocarbons derived from pine oil, resin and turpentine, the 'naval stores' products in which Hercules have specialised for many years. The heart of the new process is the production of organic peroxides as the basic intermediates. These are readily converted by means of acid catalysts to phenol and ketones, which are then separated by distillation.

The first publication relating to the preparation of cumene hydroperoxide and its subsequent cleavage to yield phenol and acetone occurred as the result of work carried out in Germany. Hercules in the United States and the Distillers Co. in England, both of whom had already been carrying on research into the oxidation of hydrocarbons, took up this work quite independently and developed attractive processes for large-scale operation. Distillers have filed a large number of patent applications in this field and have now acquired the patent rights of Hercules for Great Britain and other European countries.

In England there is a need for developing additional phenol capacity and it is likely that the economic advantages shown will make this new process the process of choice. So far, however, no announcement concerning the instal-

lation of a large-scale plant in England has been made. Distillers have already an interest in acetone production through their subsidiary, British Industrial Solvents Ltd., are consumers of phenol through their subsidiary, British Resin Products Ltd., and are interested in petroleum chemicals manufacture (and thus perhaps cumene) through their associated company, British Petroleum Chemicals Ltd.

In the meantime, Distillers have licensed the process to a French company, Progil Electrochimie, who are to build a plant near Grenoble, and they have been approached by several other interested companies in various European countries, including Belgium and Germany, who are considering the manufacture of phenol and acetone by this route.

An attractive feature of the hydrocarbon oxidation process for the manufacture of phenol is that it does not require sulphur or chlorine, two scarce materials. It seems probable, therefore, that the other new phenol plants which it has been announced are to be constructed in the United States by Oronite Chemical Co. and Allied Chemical & Dye Corp., and which will not require sulphur or chlorine, are to operate the cumene oxidation process. This is also a versatile process, enabling the production of other substituted phenols and phenolic materials by a similar series of reactions.

Viscometer discrepancies

THE difficulties of varying standards between American and British practice were recently demonstrated when a British firm of scientific equipment makers received complaints from a customer that viscosities taken with one of their Ford cup viscometers bore no relation to the viscosities on the same materials made by the customer's American associates with an American Ford cup viscometer. In an attempt to solve this serious defect, a sample of the American cup was tested and found to give results varying by 100% from the English cup. Tests were then made of the dimensions of the orifice and, although the American sample appeared to be within limits as to dimensions of orifice, it was apparently made of thin material, 16 s.w.g. or less, whereas the proper Ford cup has an orifice of a definite length.

A departure of this magnitude from the dimensions of the Ford cup standard could be expected to make a considerable difference, but it appears that there is no recognised U.S. standard for these cup viscometers, other than those actually used in the Ford laboratories, which are calibrated against their own private standards. In view of the fact that all British products will presumably be tied to the B.S. specification and will therefore be closely similar, it is recommended that users should be aware of the likelihood of discrepancies between results achieved with British instruments and any results published in America. We would suggest that for any data which is going to be compared in America and Britain some other internationally accepted viscometric reading should be taken.

Collaboration in the British gas industry

AS the result of recent discussions, the Gas Council and the Council of the Society of British Gas Industries have accepted a plan for collaboration which, while paying due regard to the fact that the problem of securing co-ordination within the gas supply industry has virtually been solved by nationalisation, recognises also that the Society remains an association of firms in competition with one

another. The plan embraces research work reserved respectively to the Gas Council and to individual member firms of the Society; research undertaken by mutual arrangement between the Gas Council or the area boards and one or more individual firms; and research offering scope for collaboration between the Gas Council and the Society on a group basis.

The first two points provide, in effect, for the continuance of what has been the practice for many years, although the wider resources of the Gas Council and the area boards should offer a larger field of opportunity both for the supply industry itself and for individual firms working in collaboration with it. To give effect to direct collaboration between the Gas Council and the Society under the third point, the Council of the Society will appoint from four to six members of their research committee to form a joint consultative committee on research with an equal number of Gas Council representatives.

Auditing energy

TO achieve optimum fuel efficiency in any factory it is necessary to prepare a complete heat balance showing on the one side the total potential energy purchased in the form of fuel or electricity and, on the other side, the quantity of heat and power generated and/or distributed to each department and/or process or, in other words, to audit the use of energy (fuel, heat and power). This requires accurate measurement which, in turn, necessitates the use of a wide range of instruments such as is rarely found in industrial establishments. The Fuel Efficiency Branch of the Ministry of Fuel and Power has a number of mobile testing units equipped to do this. The service was started in 1949 and, up to December 31, 1951, it had carried out 125 surveys which varied in duration from four days to six weeks. The savings which it showed to be attainable varied from 3.6 to 56%, the overall weighted averages being 20.8%.

The design, layout and working of these mobile fuel efficiency units were described by L. Clegg and J. Price Walters in a paper recently read before the Institute of Fuel in London. The units have been operating in all parts of the country and under a wide variety of operating conditions in chemical, soap, sugar, rubber, and cellulose film factories, cement and paper mills, steel works, tanneries, distilleries and many other plants. The Ministry's fuel engineers, although capable of making heat-balance surveys in any industrial organisation, cannot be expected to have specialised experience of every industrial process they may be called upon to examine. Consequently, the first essential is a conference with the management to discuss the function of the factory, its products, raw materials and processes used, and the physical layout, including the space heating of the buildings. A flow diagram of the process sequence is then usually constructed and the necessary measuring points discussed and agreed, an examination having previously been made of all the relevant data available on the particular process. At a second meeting, arrangements are made for installing orifice plates and, perhaps, design dimensions are given to enable the firm to manufacture these plates themselves. Some firms operate continuous processes and this calls for careful planning and close co-operation between the parties concerned. The heat and power usage is then determined for each section. When a complete survey is made, all types of plant are investigated. When this has been completed, all the observations are analysed and tabulated at headquarters prior to the pre-

paration of the report. When the report has been submitted, it is usual for the management to discuss the report with the consultants, the technical officials of the firm and the appropriate Ministry fuel engineers.

The Fuel Efficiency Advisory Service is an adjunct, and not an alternative, to the services of a consulting engineer. Its function is to stimulate the interest of managements in fuel efficiency, to present facts and to draw attention to extravagant heat-using processes and the scope for economy. The service does not include the redesign of plant or any specific advice on new equipment to be installed.

To date, the work of these mobile units, for whose services a charge is made, has certainly demonstrated the value of instrumentation and more particularly the importance of ensuring that all instruments are accurately calibrated and well maintained. It has shown, too, that fuel efficiency can be improved but that the first essential step is a thorough fuel, heat and power audit.

Phosphate production in North Africa

PLANs for modernising plant and methods of extraction of phosphates in French overseas territories will reach an important stage later this year. Output last year in North Africa was 7,000,000 tons, compared with 6,000,000 tons in 1950, and production may exceed 8,000,000 tons this year.

In Tunisia output is expected to exceed 2,000,000 tons this year and factories are being erected where the product will be concentrated. The Gafsa Co. is building a factory at a cost of 108,000,000 francs at Redeyef. A pilot plant is in operation at Metlaoui, where experiments in the electrostatic concentration and precipitation of the raw product are being carried out. If these prove satisfactory, the companies concerned will pass from the experimental to the industrial stage, which would entail an outlay of \$450,000 at Metlaoui alone.

The Tunisian Phosphate Co. is modernising its mining methods and its processes for purifying the raw product by washing and calcination. It is also renewing equipment at the La Goulette installations. The work will cost 400,000,000 francs. Also, a new shaft has been sunk at Kalsa-Djerda and is at present being equipped.

The electricity network serving the region of Kalsa-Djerda is expected to be completed this year and the company is hoping to utilise the installations at La Goulette in July, where the port installations of Tunisia have been transferred. The new port will make possible the regular loading of vessels in deep water. The new arrangements have already enabled an increase in production last year to 183,365 tons, against 123,172 in 1950, while deliveries rose from 171,052 to 206,485 tons. Production capacity for the Kalsa-Djerda group is estimated at about 400,000 tons annually, while the deposits at Meheri-Zebbeus, which are linked by rail to the port of Sfax and represent some 12,000,000 tons of phosphates, could achieve an output of 200,000 tons.

New mines are to be brought into production this year at Marco. These include the mines at Groune, which came into operation in 1940 and are expected to produce 200,000 tons this year, and those at Knouribga, where the output from the Hatane vein is to be raised to 4,000 tons/day. Production is scheduled to begin this year at the Sidi Daoui vein, which lies uncovered.

In Senegal, French West Africa, mining of phosphates at Thies is scheduled to ensure an annual production of 150,000 to 200,000 tons in the near future. Final installations are at

present being made, in particular those required for the pulverisation plant, a silo with a capacity of 1,500 cu. m. and storage and maintenance sheds at the port of Dakar. The two deposits situated in this region together represent some millions of tons of phosphates of high lime content, higher in general than those of the richest layers in Morocco.

Apart from the mining of phosphates in Senegal, the Thies Societe d'Etudes et d'Applications des Mineraux is exploiting processes for the conversion of aluminocalceous phosphates into largely soluble fertiliser. The mining and marketing of the phosphate fertiliser thus obtained under the name of *Phosphal* has been increasing since the factory went into operation in the second half of 1950. The quantity mined and purified in 1951 was 18,000 tons, compared with 4,600 in 1950.

The excess profits levy

MANY industrial leaders have seen fit to criticise the somewhat discriminating effect of this levy, announced in the new British budget. It is indeed a very severe disincentive and places a heavy penalty on those firms who have engaged in research or in industrial developments in those years which form the 'standard.' A very strong case was made by Sir George Nelson of the English Electric Co., and by the directors of the Decca Record Co., both of whom severely limited their profits in the standard years in developing processes and products which must have a very beneficial effect on the British economy in future years.

The publishers of *CHEMICAL AND PROCESS ENGINEERING* and the other journals comprising the Leonard Hill Technical Group can be said to be adversely affected in the same way.

The three standard years are just those in which the company made its great effort for wider circulations in the technical fields. It is probably not widely known that very large dollar appropriations from Marshall Aid funds were used by selected American publishers to develop their overseas circulations. These were very largely in the technical fields and, looked at through American eyes, it was a very appropriate use of these funds, as obviously the wider dissemination of American technical journals was meant to lead to greater sales for American industrial plant and technical products, raw materials, and the machinery of production.

The publications of the Leonard Hill Technical Group have always led, and aim to continue to lead, in world circulations.

In their respective fields they have, we believe, wider circulations out of their home country than their foreign colleagues in the same fields. In an attempt to preserve this position a deliberate and complete curtailment of profits, and the ploughing back to the absolute maximum, was our policy. In the year 1950, approximately 1,000,000 copies of the company's journals were dispatched, far and away the greater majority of these being sent out of England. This is a not inconsiderable figure, when it is recognised that some of our journals as, for instance, *Atomics*, must have a limited field.

This intensive drive produced a slight loss in one year and in the two subsequent years profits did not even reach 1% of turnover.

The case of the two companies quoted above, and our own, must be repeated many times. There can be no doubt that reason and logic must demand a revision of the incidence of this impost.

Chemical Engineering Progress in the Gas Industry

By G. U. Hopton, B.A. B.Sc., M.I.Chem.E., M.Inst.Gas E.

(Research Department, North Thames Gas Board)

PART 2. STORAGE, UTILISATION AND BY-PRODUCTS

In the first part of this article, which appeared in the April issue, the author discussed chemical engineering advances in the manufacture and purification of gas. Although civil and mechanical engineering are chiefly called for in storage and distribution, nevertheless chemical engineering plays an important part and this is described in the following article, together with the more obvious application of chemical engineering to the processing of the gas industry's by-products. Among the topics discussed are the prevention of gum formation, corrosion, refractories, submerged combustion, tar distillation, benzole distillation and the concentration of ammoniacal liquors.

Storage and distribution

MOST of the problems of storing and distributing gas call for mechanical and civil engineering. They are dealt with by the application of modern technique, for example, wind tunnel experiments to test the design of spirally-guided holders. The gas industry has a record of reliability of supply second to none.

Chemical engineering, nevertheless, has a part to play in both storage and distribution. An illustration of the separation of liquid droplets from gases on a very large scale is afforded by the phenomenon of gum formation in town gas. The efficient working of holders, gas boosters and distribution mains is of little value if consumers' appliances become choked by gummy deposits. A great deal of work, including a country-wide survey, was carried out in the elucidation of this problem (H. Hollings¹), as a result of which it was established that traces of nitric oxide in manufactured gas, in a concentration of a small fraction of one part per million, react with certain unsaturated hydrocarbons such as cyclopentadiene and butadiene in the presence of oxygen to form particles of gum. A gas holder allows the reaction to proceed to completion, and will bring about removal of the particles by settling, provided that the gas connections are properly arranged when working 'in and out,' and particularly if the particle size is increased by the condensation of water vapour on the gum nuclei. As a result of this work it is now appreciated that every attempt must be made to prevent air leaking into retorts, the source of nitric oxide, by accurate control of the pressure within the retort, using sensitive governors on the exhausters mains. It is preferable to wash gas with calcium chloride after and not before the holder, despite the much greater fluctuation in gas throughout which necessitates larger scrubbers. By the provision of adequate liquor storage, however, the spent calcium chloride solution can be treated at a steady rate in evaporators of normal size.

In distribution the main contributions of chemical engineering are the determination of the viscosity of gas mixtures, the measurement of pressure drop and the calculation of friction coefficients, as well as a study of the corrosion of underground mains. Substantial savings were made when wrought iron was replaced by wrapped mild steel. Hessian cloth and bitumen have been used as wrapping, but the Chemical Research Laboratory has shown that anaerobic bacteria thrive on hessian cloth, so that fibre glass is now being tried. Cathodic protection is also being studied in the field. Anodes of various kinds are buried at selected sites

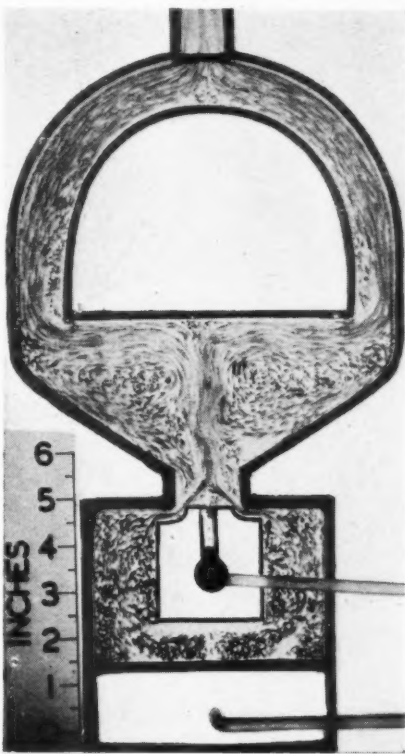


Fig. 13. Flow pattern in furnace model.

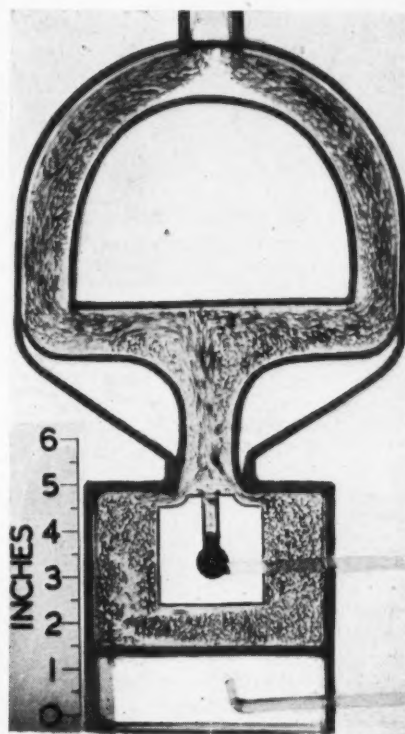


Fig. 14. Flow pattern in improved furnace model.

and measurements of potential difference are made regularly. The practical success of the method can be determined best from measurement of gas leakage, which must be done on a statistical basis over a long period. There may be difficulty in applying cathodic protection to an intricate network of small pipes which are connected by way of consumers' water heaters to the water supply system of the district.

Utilisation

The aspects of chemical engineering most generally encountered in the use of gas for heating are heat transfer and fluid

flow. The range of apparatus in which these problems are studied is very wide, including small domestic heaters, oleum stills, air heaters for the food industry, oil boiling and gum running, stereo metal heating, lead and molten salt baths for indirect heating, and furnaces. Design of appliances frequently involves other problems in chemical engineering such as mixing and agitation, and corrosion.

The production of high temperatures in industry by town gas has been described by R. F. Hayman.¹⁹ In order to attain temperatures above $1,350^{\circ}\text{C}$. two methods may be adopted, namely (a) close control of air supply by introducing all the air necessary for combustion as primary air, using gas at 3 lb./sq.in. in an injector system, or using pre-mixed air and gas, or air at 1 lb./sq.in. entraining gas at atmospheric pressure, and (b) preheating of the air by recuperation or regeneration. Refractory recuperators are essential for the highest temperatures, and more use might be made of the Babcock and Wilcox 'pebble heater'.²⁰ This may be regarded as a continuous regenerator consisting of two refractory-lined cylinders, one above the other, connected by a restricted throat. Refractory pebbles introduced into the top section form a permeable bed that becomes thoroughly heated by hot gases. The hot pebbles then trickle into the lower cylinder which serves as a heating tower for gas. The pebbles are re-cycled mechanically.

Additional insulation will also reduce fuel consumption and, where operation is intermittent, this insulation should be applied to the hot face whenever possible, since it will reduce the heat stored during heating and lost during cooling and, by lowering the average temperature, will benefit the strength of the structure. By carrying this new principle of hot-face insulation to its logical extreme one arrives at the modern concept of furnaceless heating, in which a stream of hot products of combustion from carefully designed air-blast tunnel burners of small capacity impinges on the object to be heated.

Fireclay materials, in general, are not suitable in industrial equipment for temperatures above $1,350^{\circ}\text{C}$., but the aluminous bricks used for $1,500$ to $1,600^{\circ}\text{C}$. are considerably more expensive. The choice of new refractories and insulating materials has been discussed by E. A. K. Patrick.²¹

It has often been assumed that the drop in temperature caused by increase in gas rate in many appliances denotes that the combustion chamber is too small. The study of flow patterns in combustion chambers has thrown a new light on this problem. Fig. 13 from Hayman's paper is a photograph of a two-dimensional model of a high-temperature furnace using flowing water instead of hot gases, the rate of flow being calculated to give Reynolds Number similarity. Phenol-formaldehyde moulding powder is added at the

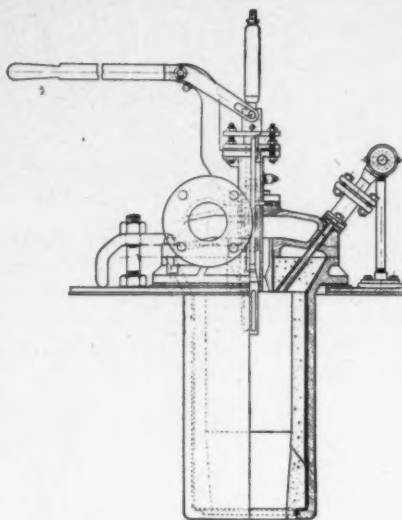


Fig. 15. Submerged combustion burner.

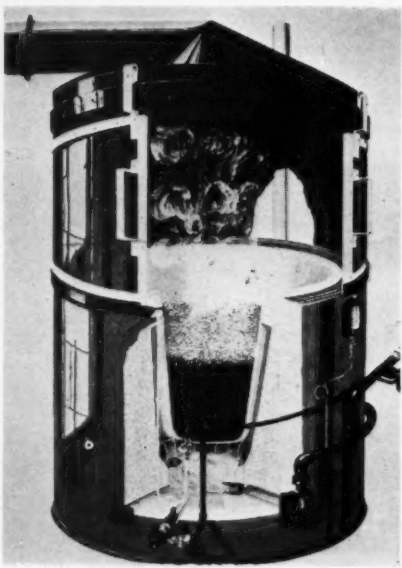


Fig. 16. Oil boiling furnace.

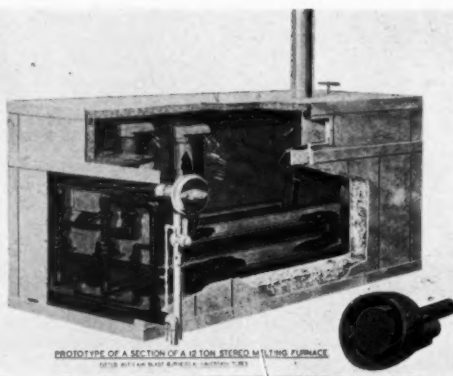


Fig. 17. Stereo metal-melting furnace.

inlet to trace the flow pattern. The furnace of which this is a model had been considered to be satisfactory until the flow pattern was studied, and was in fact a considerable improvement over earlier designs. It is seen that half of the combustion chamber is useless, since it is occupied by re-circulating gases which are partly cooled, and dilute the combustible gases, thus enlarging the flame, lowering its temperature and reducing the rate of heat transfer to the furnace. Fig. 14 shows the flow pattern in a model in which the gases enter the combustion chamber through a throat of venturi section. The combustion chamber is halved, but there is no difficulty in accommodating the water flow in the reduced space, and the re-circulation has been substantially eliminated. A prototype furnace was then designed on this principle. It reached the design temperature of $1,450^{\circ}\text{C}$. with a saving of 19% in time and gas consumption, and it maintained the desired temperature with a gas rate 11% lower than in the earlier design.

N. Swindin²² has described the problem of heating very corrosive liquids. For example, the usual method of heating pickle liquors is by passing live steam into the bath, which diminishes its usefulness by dilution. Submerged combustion has now been developed for this purpose. This method is not only suitable for solutions which no ordinary metal or alloy can resist, but in the case of pickle liquor it actually concentrates the liquor and so maintains the pickling rate. The liquors yield ferrous sulphate monohydrate in crystalline form for roasting to sulphur dioxide and conversion to sulphuric acid. Fig. 15 is a drawing of the burner. The most important advantage of submerged combustion is the generation of a large quantity of heat in a confined space, and the almost instantaneous transmission of this heat to the liquid. It is possible to release 30,000,000 B.Th.U./cu.ft./hr. in small burners, but the temperature attained is rather high for ordinary refractories and design has been based on 7,000,000 B.Th.U./cu.ft./hr. The efficiency of submerged combustion itself based on the net calorific value of the gas is 95% and, by the use of heat exchange with the hot products of combustion, very high efficiencies are also attained calculated on the gross calorific value.

Attention can be drawn only to a few examples of the utilisation of gas. Fig. 16 shows an oil-boiling furnace used in large numbers in the paint industry. Fig. 17 shows the use of air-blast burners in immersion tubes for the melting of stereo metal in the printing industry. Town gas can be used to generate reducing or neutral atmospheres as in bright annealing. The catalytic process for sulphur removal from coal gas described previously (Fig. 12) has been adapted as a compact plant for use in industry on town gas before combustion in furnaces where a sulphur-free atmos-

there is desirable. The problems of gas utilisation are in fact those for which the chemical engineer has been trained, and call for heat transfer calculations, design, pilot-plant work, testing and development of full-scale plant.

By-products

The by-products from the gas works are crude tar, crude benzole, ammoniacal liquor and spent oxide. Although in some cases these raw materials are sold to distillers, refiners, ammonia works and sulphuric acid manufacturers, there are several central works in the gas industry which treat these materials and sell higher-grade products for the use of the chemical industry.

The crude tar is distilled to give six fractions, namely light oil, carbolic oil, naphthalene oil, creosote oil, anthracene oil and pitch. Modern practice is to use a continuous pipe still in units of up to 400 tons/day. The heating is generally carried out in two stages, the first stage forming a dehydration process while the main pipe still raises the tar to distilling temperature (W. G. Adam²³). In a modern design which has been developed jointly by Koppers of Essen and the Gesellschaft für Teerverwertung the tar at 330°C. is passed into an atmospheric column which separates the feed into light oil as vapours, carbolic and naphthalene oils as side-streams, and heavy oils as bottoms. The heavy oils are reheated by heat exchange and then in the pipe still, and enter a vacuum column at 320°C., the products from which are wash oil (creosote oil) overhead, anthracene oil side-stream, and pitch below. This 'double-flash' process has the advantages of sharper anthracene fractionation, lower fuel consumption and reduced corrosion because of the lower temperature.

Although large quantities of these fractions are sold as pitch, road tar, creosote and fuel, there is an increasing tendency to work them up as purer products for sale to the chemical industry. The carbolic oil is washed with caustic soda to obtain an aqueous solution which is then decomposed by carbon dioxide to give crude carbolic acid. This is then distilled to obtain crude phenol and crude cresylic acid. The crude phenol is re-distilled from a vacuum still. The naphthalene oil from mixed coal gas is, unlike the product from coke ovens, unsuitable for the preparation of pure naphthalene by fractionation alone, and hot-pressing is used to remove traces of oily impurities from the naphthalene which crystallises out from the distilled oil. Hot-pressed naphthalene has a melting point of 79°C. and, in order to obtain a pure product of melting point above 79.5°C., it is customary to melt the material and then wash it with sulphuric acid, followed by fractional distillation under vacuum. The pure naphthalene is in great demand for the manufacture of phthalic anhydride.

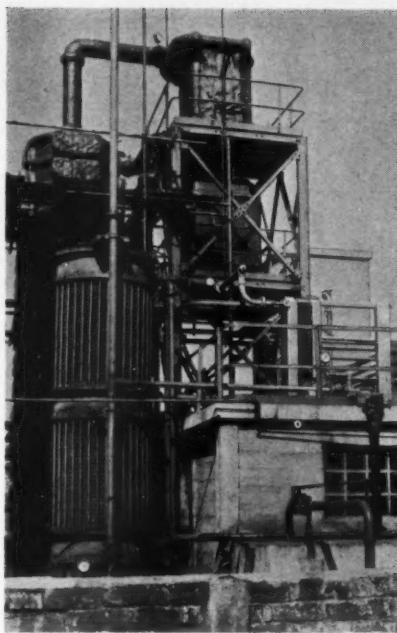


Fig. 18a. Plant for concentrating ammoniacal liquor (note Paraflow unit on extreme right).

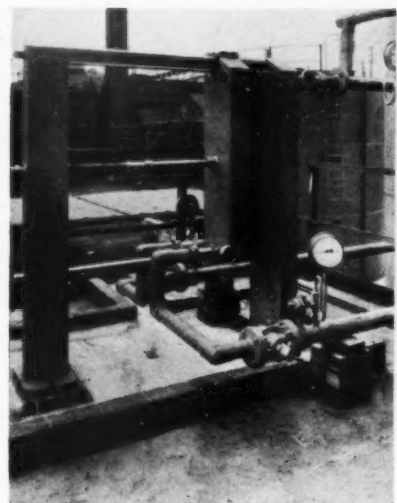


Fig. 18b. Close-up of Paraflow unit in above plant.

Tar bases (pyridine, quinoline and picoline) are obtained by washing the oil with dilute sulphuric acid in lead-lined vessels and neutralising the sulphate solution with ammonia, followed by fractional distillation.

The crude benzole recovered from coal gas is first distilled in a Barbet fractionating unit to separate carbon disulphide, benzole, toluole, xylol and naphtha. The fractions are further purified by washing with concentrated sulphuric acid, followed by fractional distillation.

Crude ammoniacal liquor is frequently concentrated on the gas works before transport to a central works. The design of liquor concentration plant involves the provision of heat exchangers and con-

densers for corrosive liquids and vapours. Fig. 18a is a photograph of a plant for concentrating crude ammoniacal liquor from 2 to 20% ammonia content, and the plant is of interest as an example of the use of heat exchange between the hot effluent leaving the still and the cold crude liquor. This heat exchange was originally carried out in the large vertical cylindrical vessel immediately to the left of the pump-house, consisting of horizontal cast-iron trays, disposed one above the other and held in position by long vertical bolts passing through flanges at the ends of the two sections of assembled trays. This unit has now been replaced by an A.P.V. Paraflow heat exchanger, which is shown mounted on the roof of the pump-house. The difference in size is striking, yet the Paraflow unit gives a better performance than the tray exchanger. The effluent from the still must contain less than 0.04% by weight of ammonia, so that highly efficient stills should be provided. The disposal of this effluent, and other effluents from gas works practice, is a nation-wide problem which has been discussed by E. H. M. Badger.²⁴ The most satisfactory solution appears to be controlled discharge to the sewers for biochemical oxidation at a sewage works. It is important to reduce oxygen absorption of the liquor so as to minimise the load on the percolating filters, and dephenolation of the crude ammoniacal liquor is desirable. In this process the ammoniacal liquor is treated with a solvent for phenol such as creosote wash oil from tar distillation. In one large plant this treatment is carried out in Holley-Mott washers before passage to the ammonia stills, and the spent wash oil is then regenerated by washing with caustic soda solution. The phenols are set free from the soda solution by treatment with carbon dioxide and are worked up for sale. The sodium carbonate is causticised for recovery of caustic soda. This plant has been fully described by D. G. Murdoch and M. Cuckney.²⁵ Fig. 19 taken from their paper shows a flow diagram of the plant. Recent work has shown that substantial reduction in the size of plant may be achieved by replacing the Holley-Mott washers by centrifugal pumps, followed by simple gravity separators. Work has also been carried out on the use of selective solvents for phenol such as butyl acetate (phenosolvan).

Ammoniacal liquor is distilled into sulphuric acid for production of ammonium sulphate, the plant comprising stills, saturators, centrifuges and drying chambers. The gases which pass unabsorbed through the saturator consist of the hydrogen sulphide and carbon dioxide originally present in the ammoniacal liquor, and the hydrogen sulphide may be recovered by passage of these gases to a 'wet' contact plant in which the gases are burned with air to give water vapour and sulphur dioxide, followed by conversion of the sulphur dioxide to sulphur trioxide over a vanadium catalyst, and cooling combined with absorption

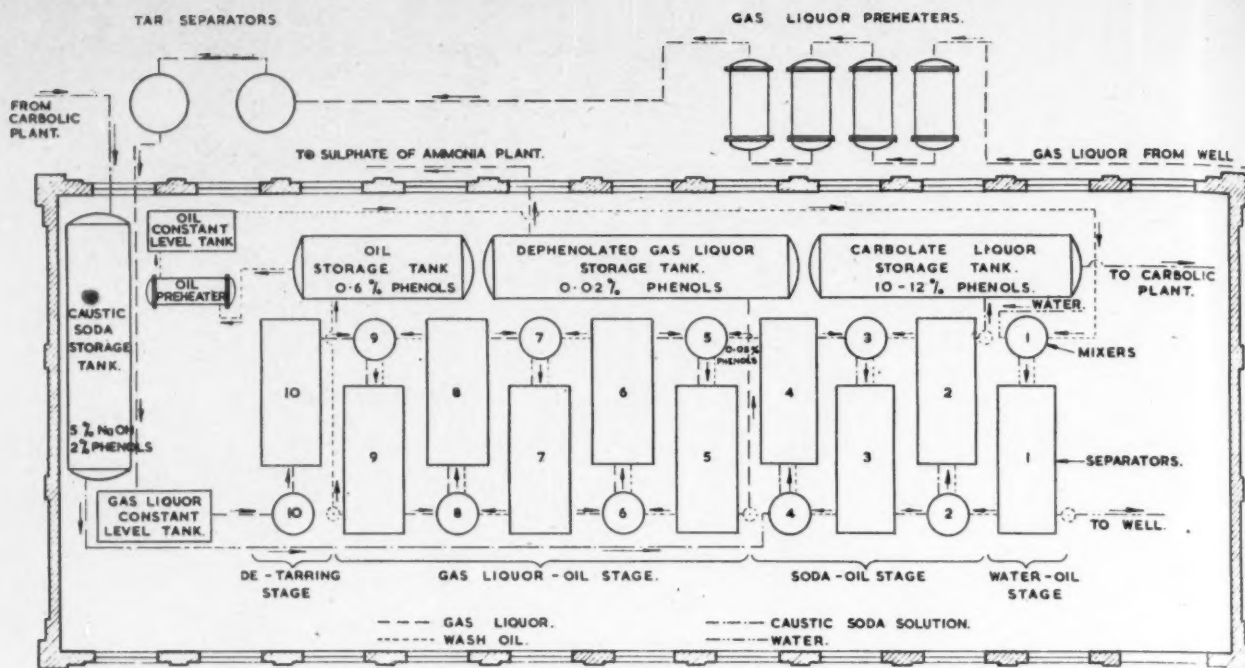


Fig. 19. Flow diagram of dephenolation plant.

of the sulphur trioxide in the condensed water vapour to yield sulphuric acid. This sulphuric acid represents, however, a relatively small amount in comparison with the large production of chamber acid from the burning of spent oxide obtained in the removal of hydrogen sulphide from manufactured gas, for which purpose it is customary to use Mills-Packard plants.

From this short account of the by-products of gas manufacture it will be seen that a great variety of chemical engineering operations is practised. Research to find new processes and improve existing practice is important. Efforts to improve operation by automatic control, and to increase efficiency and reduce steam consumption by the application of new advances, are constantly made. As an example of the development of a new process, attention may be drawn to the need for the production of elemental sulphur. A process has recently been devised in the laboratory for the treatment of spent oxide with hot toluene so as to extract the sulphur, followed by cooling of the hot solution under carefully controlled conditions, and fusion of the separated crystals in order to minimise inclusion of tar. Sulphur of over 99.9% purity has been obtained from spent oxide containing 49.2% of sulphur and 1.2% of tar. Fig. 20 is a photograph of a pilot plant using this process, which has been described by F. A. Burden and W. B. S. Newling.²⁶

Opportunities for chemical engineers in the gas industry

From this brief survey it will be seen that the fundamental principles of chemical engineering are applied in the manu-

facture, purification and utilisation of gas, and in the treatment of the by-products. An understanding of these principles is essential for the efficient control of plant and the introduction of new processes. While the gas industry does not, with a few exceptions, manufacture the plant it uses, it exerts a profound influence on design by virtue of its special knowledge and experience, leading in collaboration with the makers to continual improvements in apparatus. As new processes are discovered, many in the research laboratories

of the gas industry itself, new problems in the transition to the full scale arise, problems which the chemical engineer is specially fitted to tackle.

The importance of chemical engineering is recognised throughout the gas industry, which offers many opportunities for design, development, testing and control over a wide range of processes.

ACKNOWLEDGMENTS

Figs. 13, 14 and 20, Institution of Gas Engineers; Fig. 19, Institution of Chemical Engineers.

(References are on page 307)

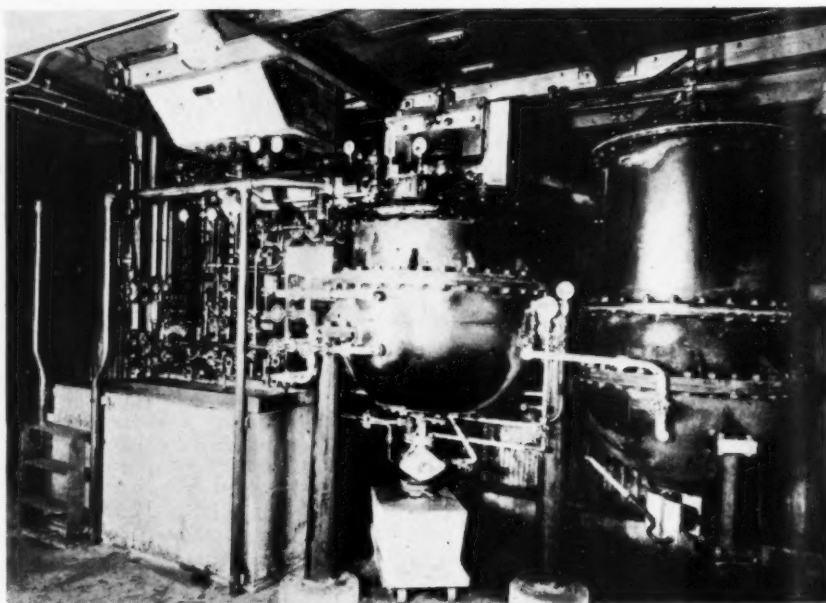


Fig. 20. Pilot plant for recovery of pure sulphur from spent oxide.

Simplification in Stainless Steel Specifications

INSTITUTION OF CHEMICAL ENGINEERS SYMPOSIUM

The need for and the possibilities of simplification in stainless steel specifications were fully explored by the Institution of Chemical Engineers in the course of a half-day meeting held in London on April 1, 1952. The chair was taken by Dr. F. A. Freeth, a Vice-President of the Institution, and in the course of the meeting the views of the steel maker, the foundryman, the semi-finished products maker, the fabricator and the user, together with suggestions for substitute stainless steels, were fully discussed. As will be gathered from our report, the general opinion was that there were far too many specifications, many of them far too much alike, but the reasons given and the suggestions for alteration and improvement were almost as numerous as the speakers.

THE proceedings opened with an introduction to the whole subject by Mr. J. L. SWEETEN (Metal Propellers Ltd.). At the moment it was a national necessity to increase production and an intelligent limitation of stainless steel specifications would seem to offer a way. The spate of specifications in recent years seemed to suggest that stainless steel was a very important product. In 1939 there were no special stainless steels; in 1952 there were too many.

In the survey of existing specifications which he made Mr. Sweeten pointed out that he was concerned with specifications only and took no count of mechanical properties. At the moment it was important to conserve certain of our raw materials; nickel, molybdenum and niobium were largely imported from dollar sources and they should be confined to really essential uses. Many of the specifications seemed to include those metals in varying amounts, and often quite unnecessarily as far as any difference in the metal produced was discoverable.

As a first step to improvement he suggested that B.S. 1449, 1601, 1750, should be withdrawn and B.S. 1501 should stand in a simplified form to meet the requirements of the petroleum industry.

Steel maker's views

As a steel maker, Mr. E. SMITH (Firth-Vickers Stainless Steels Ltd.) did not approve of the suggested alterations because he thought they were not improvements. The British Standard Specifications gave the answer—production—and he thought it would not be in the interests of the nation or of industry to alter present specifications.

It would be much better to form a standing committee of the Institute and include in it plant fabricators and users, to consider the general problems as they arose and to discuss courses of action. They could achieve more by such advisory means than would be possible by the more rigid method of reliance solely on specification. To choose a material from a table on composition was not the best way of selecting a material for a given purpose.

Foundryman's views

Mr. M. M. HALLETT (Sheepbridge

Engineering Ltd. and Sheepbridge Steel Castings Ltd.) pointed out that any specification was in the nature of a compromise and the job of the foundry was to provide sound castings at a reasonable price from available raw materials with available equipment. Soundness was more important than meeting the chemical composition exactly and it was also vital that the cost should be right. If specifications were made too strict the cost went up and they became unusable. Too many specifications were a serious bar to getting a satisfactory job—a small number were extremely desirable.

Generally, from the foundry angle, they did not see very much advantage in the new specifications. The existing British Standards gave them a rapidly produced series of alloys which did not cause them particular concern. The new specifications certainly included one or two steels which were not covered by the B.S. 182, which might be incorporated.

With regard to the conservation of the more scarce raw materials the most difficult was niobium and, if one wanted a really good foundry alloy which gave sound castings with a good surface in a well-proved steel, it was almost essential that niobium should be used.

Molybdenum also was not too cheap, but they had to have a reasonable amount—something of the order of 2% or over—to give a reasonable degree of resistance to sulphuric acid. Similarly they could not play too many tricks with nickel. No one used more of these scarce and costly materials than they possibly could.

Semi-finished products maker's views

DR. J. W. JENKIN (Tube Investments (Research) Ltd.) spoke from the point of view of the semi-finished products maker and was in favour of fewer specifications. In any one works too many varieties in composition resulted in change of technique and increased risk of confusion. No doubt they could all agree on the general principles of co-ordination, but it did not follow that it was a simple matter in the case of stainless steel.

There was an understandable prejudice against change from accepted practice without adequate reasons. At the same time every specification should be as wide

as possible so as to serve the maximum number of end uses, having regard, of course, to the specialist requirements of every kind of operation from the making of the raw material to the finished product.

Dr. Jenkin then outlined a number of factors to which he thought regard should be paid by those who were seeking to simplify specifications. Among the factors enumerated were a consideration of the technique of manufacture at every stage, of the various forms and shapes into which the material might finally be used; the importance of ensuring the maximum number of satisfactory products for the minimum number of varieties in composition; the prejudice against change from established practice without most cogent reasons; the fact that existing compositions had been built up on many years of well-established experience, and any change would have to be gradual; and the necessity to avoid any change that would worsen the supply position.

Commenting on these views, Mr. TUFHOLM (Fox & Co., Sheffield) said it seemed to him that many people made a specification merely for the sake of making one. The E.N. 58 covered a very wide range of specifications and seemed to cover more than all that was covered by private specification.

Then again the 16 to 18 chromium was quite satisfactory, while the 20 to 22 could well be widened. The austenitic range of 8 to 9% nickel was unnecessarily narrow and even the 17 to 19 chromium could be widened with advantage. The austenitic C and D were again very narrow ranges in nickel and chromium and could well be widened. In the martensitic and austenitic specifications the sulphur and the phosphorus had been put down as 0.4 maximum. While they did not object to that they did not see why 0.5 could not have been put down to make it consistent throughout the whole range.

There was another point in connection with specifications: the fewer specifications there were the easier it was for a supplier to obtain material off the shelf. If a special composition was wanted it meant making the whole of the cast specially, whereas if it could be taken from a standard product the fewer specifications they had the better for all concerned from a production angle.

MR. SMITH pointed out that there were probably six main steel makers in the country and each of them had five different classes of steel; that gave 30 different types of steel to start with. If those six firms could be persuaded to reduce their ranges that would be a great advance from the point of view of the fabricator. However, he thought the steel maker would not like it because he would never be sure with what he might be charged. It would also, probably, not be to the advantage of the ultimate user, and he was the man who mattered. Was he going to be satisfied with plant made from steel of which the fabricator did not know the maker? Admittedly it might comply with specification, but he thought he would hardly be satisfied.

MR. WATSON said he could not help remembering that ten years ago the Government specification for stainless steel was 'S.S.' That was 'stainless steel' for all purposes, and it worked quite well, and he could not help thinking they were getting into a tremendous muddle over those percentages of carbon, silicon or phosphorus and other materials. There was an enormous number of specifications, but the average user did not know what they meant. All he knew with certainty was the stress and the use to which the material was to be put. Surely if he asked the maker to provide a material which would do what he wanted he had no need to bother about the chemical analysis. He did not say that they should entirely scrap the chemical analysis, but he thought a great deal too much importance had been given to it. The whole thing should be put the other way round. They should be told 'the following steels are suitable for such and such purposes' or steels should be classed by tensile limits, or their suitability for welding, or that they could not be welded, and so on.

A member of the Institution, speaking from the point of view of the fabricator, said that as far as he could see the customer only had three questions which he asked: 'How much will the job cost?'; 'How soon can I get it?'; and 'Will it work?' If they could answer those three questions he did not care whose stainless steel went into the job. If simplification of the standards would help them to answer those questions better than they had in the past, then it would be a definite advantage.

MR. HALLETT said it seemed there was agreement on the need for simplification but there seemed to be objections on the part of stainless steel manufacturers. They were all convinced of the necessity for simplification of specification and it would be a good thing if in the interests of national economy the prejudices of the steel makers could be sensibly overcome to the benefit of all concerned.

Fabricator's views

Following a break for tea, the views of the fabricator and the user of stainless

steels were put before the meeting, together with a review of the position of, and the possibility of there being substitutes for, stainless steel.

MR. J. F. LANCASTER (A.P.V. Co. Ltd.), who spoke as a fabricator, said he was mainly interested in three qualities, weldability, cold and hot working and machineability. Discussing the suggested limitation of specification, he said there should be in the specifications room for the permissible addition of titanium, which gave advantages in welding and helped towards a sound corrosion-free joint. Again, good cold-working properties depended on keeping the carbon content low. Another defect of the drafts was that they made no provision for free machineability. Stainless steel was most awkward in the machine shop and anything that would improve those qualities would be of great value. Phosphorus, sulphur, selenium and lead had all been added in that respect.

The proposed draft specifications as they stood were no great advance on existing specifications such as the E.M. series, and it was, if anything, not so good as the Stainless Steel Specification Association's and B.S.I. 1500. Moreover, stainless steel made by different manufacturers did, in fact, differ marginally in corrosion resistance. In nine out of ten cases it would not matter, but in the tenth case it might be vital. They should not be complacent about the matter, for it pointed to a gap in their knowledge.

But those points aside, he thought he had to come down on Mr. Sweeten's side in agreeing that there was a very strong case for a simplification and a drawing together of the B.S. specifications.

The general use of the B.S. specification would be a good thing from the point of view of the export trade. The American A.S.I. type numbers had gained commercial currency nearly all over the world and it was time we caught up with that.

The chemical engineer who was building a plant in some type of material for some specific corrosion-resistance duty should be able to call for his needs by a given specification number whether it was sheet, tube or castings; all should have the same corrosion resistance. Simplification would best be met by producing a family of specifications having type numbers for materials with a known corrosion resistance and a particular specification for different types of product—sheet, tube, castings and the like.

User's views

MR. F. H. KEATING (I.C.I. Ltd., Billingham Division) said that, of the many groups of specifications which had been mentioned, the B.S. 1500 seemed to be a considerable advance on earlier British Standards and came very close indeed to meeting requirements essential for the chemical industry. There were still certain difficulties, but the three parties concerned could probably produce a group of speci-

fications which would be acceptable to a large part of British industry. Such a set of specifications should be as simple as possible and should be agreed by all parties. There should be no great difficulty in achieving such an agreement, and for his part he would welcome such an opportunity. In any such attempt it should not be overlooked that the Americans were using considerable quantities of extra low carbon materials at the present time. Any group of such specifications should provide for the inclusion of the extra low carbon grades because, he thought, they would have a place in the chemical industry within the next few years.

Substitute stainless steels

The purpose of the symposium, said MR. G. A. DUMMETT (A.P.V. Co. Ltd.), who spoke on substitute stainless steels, was to present to the meeting a review of the sort of alternative substitute stainless steels which would economise in nickel and molybdenum, and not to suggest absolute specifications. The idea was to suggest the particular lines that might be taken in framing such specifications. They were, therefore, substitute stainless steels and not substitutes for stainless steel. There was no substitute for ordinary austenitic stainless steel, but it might be replaced for a number of duties by stainless iron. The main difficulty lay less with the user or foundryman than with the steel maker, whose production might be dislocated by the substitute alloys requiring different treatment to that for which his works had been designed.

Scarce metals

A member of the Metals Economy Branch of the Ministry of Supply, MR. D. A. OLIVER, speaking of metals that were scarce, warned his audience not to believe the wild stories about scarce materials, because they did not get scarce in a six weeks' cycle—not as a rule. They had to think in terms of a year's supply before they could say that there was a serious national scarcity or the reverse.

As regards nickel they would have to be careful for some years to come if they were to expand their national efforts in the way needed. He thought it a fair statement of the position to say that we had got to be permanently careful of our nickel, but as regards chromium the general position was good. Niobium presented a peculiar picture. To read the papers one would gather that there was a world shortage. As concerned America that was true, but from the point of view of this country we had been fortunate in having a ration and we had lived within that ration. On the aeronautical side we had managed to effect savings which had made the position easier, so, if used skilfully and not wastefully, they might find they would be able to obtain supplies.

There was some rather grim news about

selenium, which had been mentioned as improving machineability. It could not be used for such purposes and would not be available for the next few years. At the moment, selenium was urgently wanted for rectifiers and the world supply was inadequate. To improve machineability in steel, sulphur or zirconium could be added and were equally as good.

MR. RAWSE, who said he spoke as a chemical engineer mainly engaged in plant design, said he thought he was not the only one who would be interested in a specification for stainless steel which would resist hydrochloric acid.

Summing up

DR. E. H. T. HOBLYN, director of the British Chemical Plant Manufacturers' Association, summing up the discussion, said he thought they should always remember that most countries were extremely prodigal in their use of the materials which Nature provided. We had already had a sharp lesson over sulphur and one or two frights from nickel and molybdenum. Even if the position did look a little better now, he thought we should be failing in our duty if we did not take every opportunity of saving those potentially scarce alloying metals.

But in so doing let them preserve a balance and not, on the one hand, attempt a gold-plated job which would last for ever when something which was slightly inferior would do the job quite well, or, on the other hand, get so economy mad that they built something which would not last at all.

In the matter of substitute steels could we not give a lot more attention to chromium and chrome-magnesium steels and the low-carbon stainless steels and to the possibility of producing on a commercial basis those nitrogen-containing steels? He believed the Germans had talked about it in 1940.

They had well ventilated the subject and it was obvious something would have to be done.

A report on the symposium might be submitted to the B.S.I., accompanied by a strong recommendation—which he thought they would not need—but he doubted whether it would be of any value. A better approach was to prepare a set of parallel specifications for substitute steels as an insurance against a possible emergency and for present use, and in doing that he suggested they should not try to make change for the sake of change.

Any such action would have the solid backing of all sections of the industry concerned. They were all aware of the difficulties, but do let them face them and tackle the job in a real sense of give and take, free of personal fads and fancies. They should be able to produce specifications which everyone would not only use, but want to use, and departures from it could be easily and actively discouraged.

Report on 1951 A.M.I.Chem.E. Exam.

ONE hundred and ten candidates sat for the examination, of whom 45% satisfied the examiners. Failures were highest in the written papers, the questions in which were either in a form requiring more fundamental treatment than usual, or which dealt with subjects within the syllabus less frequently set in past years.

Home Paper 'A'

Home Paper 'A' (the design problem) was generally well answered. At the same time, although the literature was, in general, thoroughly surveyed, the extracted information was not always presented in such a form as to make the process selected clear to one unfamiliar with it.

The design calculations were well done. The drawings were better than in preceding years, but there is still room for considerable improvement in this regard. In particular, insufficient attention was paid to the layout of the plant on the site.

Home Paper 'B'

Home Paper 'B' (the essay) was answered satisfactorily, grammar and style showing appreciable improvement over past years.

Paper 'C'

Paper 'C' (conveyance and storage of materials: production, transference and conservation of heat) was not very satisfactorily answered. A few candidates obtained high marks, but many appeared to lack understanding of the fundamental basis of the equations used in problems of fluid flow and heat transfer.

Paper 'D'

Paper 'D' (treatment of materials) was, in general, well answered. The drawings which accompanied the descriptive matter were, however, poor. The chemical engineer should be capable of making free-hand sketches to explain adequately the main features of the plant which he is attempting to describe.

Paper 'E'

Paper 'E' (chemical plant construction, factory design and construction, and industrial economics) had, as usual, to be answered without access to books of reference. Answers to the compulsory question—on materials of construction—were generally inadequate. The time allowed for this should be sufficient for a list of materials available, the reasons for the choice of one material, a note on methods of fabrication and a sketch of the proposed plant, to be completed.

The compulsory question on the fundamental principles of chemical engineering was not answered as satisfactorily as could be expected. Moreover, the legal obligations of chemical engineers were also not well understood.

Paper 'F'

Paper 'F' (engineering drawing) produced fewer good answers than had been anticipated. The detail drawing was, in general, satisfactorily done, but, in the written description of the equipment, few candidates mentioned the more important features of the design.

Welsh chemical industries

For a great many years the manufacture of Portland cement has been carried on at three works in Glamorganshire, and these works now produce some 450,000 tons p.a. The first new cement works to commence production in Great Britain after the war started up at Padeswood in Flintshire in 1950. Output is now over 200,000 tons p.a.

All the nylon yarn now made in Britain is produced at Pontypool and the first production target of 10,000,000 lb. nylon yarn p.a. has been reached. The construction of a new plant started a few months ago and when it comes into operation in about three years' time, it will provide for a three-fold increase in the output of nylon yarn and staple fibre. The Pontypool plant already provides employment for 3,000 men and 600 women. At present well over £10,000,000 p.a. of nylon goods are exported from Britain.

These facts are given in the 1952 Industrial Directory of Wales and Monmouthshire in which it is stated that there are some 36 firms in this area devoted to the manufacture of chemicals, synthetic fibres, and pharmaceuticals. Another big Welsh industry is the National Oil Refineries Ltd. at Llandarcy. Oil refining was commenced at Llandarcy in 1921 and in 1938, less than 500,000 tons of petroleum products were produced. Later plans provided for an expansion to about 2,000,000 tons p.a. and additional plant for the increased tonnage was completed in 1949. Further equipment for special products is being installed now and the whole project is scheduled to be completed early in 1953.

Gas Industry

(Concluded from page 304)

REFERENCES

(Numbered consecutively with those of Part 1)

- ¹⁸H. Hollings: *Trans. Inst. Gas. Eng.*, 1936, 86, pp. 501-577.
- ¹⁹R. F. Hayman: *Institution of Gas Engineers*, 1951, publication No. 396.
- ²⁰C. L. Norton, jun.: *Chem. & Met. Eng.*, 1946, 53 (7), pp. 116-119.
- ²¹E. A. K. Patrick: *Ceramics*, 1950, 2 (14), pp. 69-75.
- ²²N. Swindin: *Trans. Inst. Chem. Eng.*, 1949, 27, pp. 209-221.
- ²³W. G. Adam: *J. Junior Inst. of Engineers*, 1945, 55, pp. 325-362.
- ²⁴E. H. M. Badger: *Institution of Gas Engineers*, 1949, publication No. 360.
- ²⁵D. G. Murdoch and M. Cuckney: *Trans. Inst. Chem. Eng.*, 1946, 24, pp. 90-101.
- ²⁶F. A. Burden and W. B. S. Newling: *Institution of Gas Engineers*, 1951, publication No. 397.

Organic Chemicals from Natural Gas—2

By R. J. S. Jennings, M.A., A.R.I.C.

In the first part of this article which appeared in **CHEMICAL & PROCESS ENGINEERING** last month (pp. 243-246), the author, after discussing generally the manufacture of chemicals from natural gas, dealt in detail with the production of acetylene from methane. In this concluding part of his article he considers in detail the production of acetone, methanol, formaldehyde and acetaldehyde.

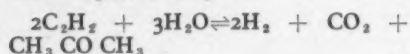
2. CONVERSION OF ACETYLENE TO ACETONE

THIS conversion can be brought about either by employing dilute acetylene gas or using acetylene of high purity.

Using dilute acetylene gas

This dilute gas was made from the partial combustion of methane as already described.^{14, 16, 22}

The hydration of acetylene to acetone can be represented by:



G. O. Morrison²³ is of the opinion that the reaction takes place in the following stages, acetylene \rightarrow acetaldehyde \rightarrow acetic acid \rightarrow acetone.

The dilute acetylene gas¹⁴ at 80°C. was heat-exchanged to 350°C. and then introduced into the reactor which contained three beds of catalyst. The temperature was controlled by the injection of cold reaction gas between each bed and the rates adjusted to have a temperature gradient of 350 to 450°C. across each bed. The details of the reactor are given in a diagram.¹⁴ The catalyst was made from powdered ZnO made into a paste with dextrin and extruded. Ten cubic metres of catalyst volume was required to treat the dilute acetylene gas obtained from 800 m.³/hr. of methane. The catalyst lasted for a period of four weeks before it was regenerated with air. With 9% C₂H₂ in the inlet to the reactors, the exit gas contained 0.5 to 1.0%. The acetone was absorbed in water after the reaction to give a 2% acetone solution. The yield of acetone after distillation was 80% of the theoretical. For final purification the acetone was treated with solid sodium hydroxide at room temperature and redistilled. The acetone obtained was then of high purity. After acetone removal, the 8,000 m.³/hr. of total gas was heated by interchange to 700°C. in Sicromal interchangers, the requisite amount of O₂ added and the mixture burned in a 4 m.³ space. It then passed over a Ni on Mg O catalyst of 2 m.³ capacity, whereby the temperature of the exit gases was reduced by the endothermic reaction to 800°C., and the methane content was reduced from 5% to 0.1 to 0.3%. The resulting synthesis gas was suitable for methanol production.

Using concentrated gas

The gas used by Shawinigan Chemicals obtained from carbide and therefore of high acetylene content, is scrubbed with sulphuric acid and sodium hydroxide before being fed to reactors containing a catalyst prepared by precipitating ferric hydroxide from ferric chloride solution by ammonia, mixing the precipitate with zinc oxide and grinding in a ball mill with 3/8 in. iron balls.²⁴

The mill contents, including the balls, which serve to dissipate reaction heat and increase catalyst surface, are transferred to the reactor, dried and hydrated.

Acetylene/steam in 1/10 vol./vol. proportion is fed to the reactor.

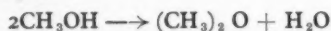
The products pass through a condenser and scrubber eliminating H₂ and CO₂, and the liquid product (10% acetone) is rectified to make pure acetone. The capacity of the 22 reactors is 300 tons/month.

3. CONVERSION OF SYNTHESIS GAS TO METHANOL

The Methanol production technique at Oppau was based on experience gained in the manufacture of ammonia and isobutyl alcohol. There were two complete methanol synthesis loops in operation at the ammonia plant, each having a capacity of 90 to 100 tons/day. Methanol was produced from the H₂ + CO of the synthesis gas at high pressure and temperature in the presence of a promoted zinc chromite catalyst, according to the following reaction:



The following undesirable side reaction, giving small amounts of dimethyl ether also took place:



If the temperature of the catalyst was allowed to rise above about 400°C., the following highly exothermic reaction ensued, with further increase in temperature:



Although the equipment was generally designed for a maximum pressure of 325 atm. the usual operating pressure at Oppau was 250 to 260 atm. Condensate removed from the product separator containing methanol, water, dimethyl ether, higher alcohols and impurities was known

as 'raw methanol,' and was sent to the distillation system.

Operating conditions. The percentage of CO in the gas entering the converters was adjusted to less than 20% in order to prevent the formation of appreciable quantities of higher alcohols.

The maximum operating temperature in the catalyst bed was between 360 and 390°C. It was pointed out that it was very important to maintain a constant pressure drop across the converter, as a sudden variation of even a few atmospheres increased the amount of undesirable components in the raw methanol.

The raw methanol leaving the synthesis loop had the following approximate composition:

CH ₃ OH	..	..	..	90
Higher alcohols and ketones	0.8 to 1			
(CH ₃) ₂ O	..	..	..	1 to 2
H ₂ O	..	..	..	6 to 8

The conversion per pass was between 12 and 16% of the amount of CO fed to the converter. The yield of methanol contained in the raw product based on the CO fed into the system was about 62%.

Methanol distillation. Dimethyl ether was distilled off and the 98% pure ether used for making dimethyl sulphate and dimethyl aniline.

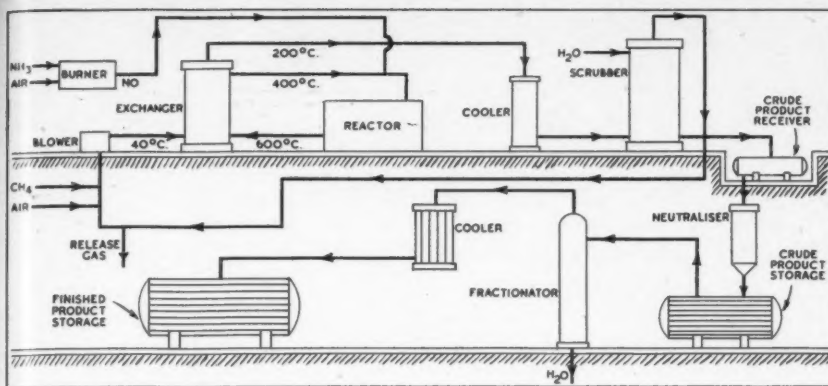
The product, 95% methanol and 5% methyl isobutyl ether, methylal, methyl formate, etc., was further refined in order to obtain a product pure enough for formaldehyde manufacture.

Yields. One ton of raw methanol furnished:

	kgm.
Pure methanol	.. 780 to 830
95% methanol (above)	.. 30 to 100
Dimethyl ether	.. 20
Higher alcohols	.. 0.2 to 0.3

The yield of pure methanol, based on the methanol content of raw methanol fed to the system, was approximately 89%.

M. L. Kastens *et al.*²⁵ relates that all but one of the synthetic methanol plants in the U.S.A. built since the war are based on natural gas. Economic considerations primarily are responsible for the change-over. However, the economic advantage of synthesis from natural gas may prove to be transitory. Since World War II natural gas prices f.o.b. wellhead have been increased from 1 to 3 cents. to 6 to 9 cents.



Gutehoffnungshuette process for converting methane to formaldehyde.

Economists predict that the climb may go on to as much as 18 cents. At somewhere near this level the coal-natural gas economics may again balance in certain areas where low cost coal is available.

Low-pressure methanol synthesis

A new synthesis of methanol has been developed²⁶ which was carried out at 30 atm. as compared with the usual operation at 250 atm. The work was carried out on a laboratory scale and had resulted in the assembly of a pilot plant at Wolfgang near Hanau.

In view of the large saving in equipment and operation, this synthesis, if carried through to commercial realisation, may be of great interest to the producers of methanol.

The synthesis uses carbon monoxide and hydrogen. The net reactions involved are:

- (i) $\text{CH}_3\text{OH} + \text{CO} \rightarrow \text{CH}_3\text{OCHO}$.
- (ii) $\text{CH}_3\text{OCHO} + 2\text{H}_2 \rightarrow 2\text{CH}_3\text{OH}$.
- (i) and (ii) $\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH}$.

The catalyst for reaction (i) was sodium methylate dissolved in methanol; the catalyst for the second reaction was a typical hydrogenation catalyst of copper, chromium and barium oxide. Although two molecules of methanol were formed, one was recycled for reaction (i) and one was product, so that the result was the combination of one molecule of CO and two of H_2 to give one of methanol.

Overall yields of 95% conversion to methanol were claimed.

Reaction (i) was conducted as follows for a batch process:

Sodium metal, 5.8 gm., was dissolved in 100 gm. methanol; this made approximately a 13% solution of sodium methylate. The solution was charged to an autoclave and air was removed by displacement with CO, and then a pressure of 30 atm. was produced by feeding CO. The temperature was raised to 80°C. and, as the CO reacted, the pressure was maintained at 30 atm. by feeding CO. The temperature was held at 80°C. The yield of methyl formate was about 38% of

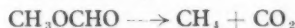
theoretical. In continuous operation the yield of methyl formate was about 25%. The heat of reaction for step (i) was about 9 kgm. cal. mol. of methanol.

It was essential in this operation that the reactant should be free of water and CO_2 , as either of these react with the catalyst, so that if present in sufficient quantity they would preclude the desired reaction. The presence of H_2 in the CO used in this step tended to decrease the yield of methyl formate. It was not essential, however, to remove the hydrogen completely, because experiments with acceptable yields had been made with CO containing 30 vol. % H_2 .

The crude product from the addition of CO to methanol was separated from the catalyst salts by distillation of methanol and methyl formate, and was then hydrogenated in a silver-plated tube containing a copper-chromium-barium oxide catalyst. If the hydrogenation temperature was too high (greater than 185°C.) two side reactions took place, the first of which decreased the yield of methanol but did not decrease the efficiency, in that the products were methanol and CO which could be recycled in a large installation:



The second reaction not only decreased the yield but also decreased the efficiency, and is represented by:



The products of the hydrogenation were separated by fractional distillation. The distillation was not complicated in that the products boiled at widely different temperatures, methyl formate 31.8°C., and methanol 64.7°C. No azeotropes were formed in the fractionation.

To apply the above process successfully to mixtures of CO and H_2 obtained from partial combustion of methane would necessitate adjusting the gaseous mixture firstly to a high CO content and then to high H_2 content.

4. PRODUCTION OF FORMALDEHYDE

Formaldehyde may be produced either by the catalytic air-oxidation of methanol or directly by partial oxidation of methane.

Conversion of methanol to formaldehyde

The Germans made formaldehyde by air oxidation of methanol over a silver catalyst.¹⁵ A 60% mixture of water and methanol was passed with air over the catalyst at 650 to 700°C. The formaldehyde was obtained as 30% solution. The methanol used had to be very pure and free from iron carbonyl.

M. L. Kastens²⁵ says that oxidation of methanol to formaldehyde accounts for almost half the total American production of the former. Two-thirds of the remaining production today is used as automobile antifreeze. The major consumption of formaldehyde is in the manufacture of phenol-formaldehyde resins.

The Durez Plastics and Chemicals Inc. of America produces its own phenol and formaldehyde synthetically, the latter being obtained by oxidation of methanol.²⁷ The rated capacity of the plant is 91,000 lb. of formalin (37% by wt. of formaldehyde in water) per day. Conversion is about 65% per pass, therefore it is necessary to recycle unreacted methanol. Less than 1% methanol is left in the finished product.

Formaldehyde is formed by two reactions, both of which occur simultaneously. Under proper operating conditions about 55% of the formaldehyde results from the exothermic oxidation:



while about 45% is formed by the endothermic reaction:



Parasitic reactions result also in formation of minor percentages of CO and CO_2 , while a dirty catalyst can produce some formic acid. Failure to cool the reaction gases quickly can produce methylal, $\text{HCH}(\text{OCH}_3)_2$ from methanol and formaldehyde.

Conditions. Washed air and methanol vapour are mixed in roughly equal proportions by volume and passed through a bed of prepared silver catalyst where controlled combustion at about 635°C. yields a mixture of CH_2O , CH_3OH , H_2O , CO, CO_2 , H_2 and N_2 . The hot mixture of gases issuing from the burner is quenched at once in absorption towers. The formaldehyde-methanol liquors are then distilled to produce a solution of formaldehyde in water with less than 1% methanol, and the separated methanol can be used again in a continuous process.

Monsanto produce their formaldehyde by a similar process²⁸ and make nearly 5 tons hr. of formalin with 2% methanol.

C. P. Neideg²⁹ mentions some plants using iron-molybdenum catalyst to yield substantially methanol-free formaldehyde. The yields with this catalyst are slightly higher than with the silver catalyst.

J. V. Hightower³⁰ describes the McCarthy Chemical Co.'s process using a metallic copper catalyst.

Direct conversion of methane to formaldehyde

Gutehoffnungshuette process. The German Gutehoffnungshuette process was carried out on a commercial scale during the war and is still operating satisfactorily.³¹

The process, in brief, is a low-pressure, high-temperature partial oxidation of methane with air to formaldehyde in the presence of a minute amount of nitric oxide as catalyst.

The raw material is natural gas containing 98% CH₄. The methane and air in volume ratio of 1.0:3.7 are added separately to unreacted product gas, water-scrubbed free of formaldehyde, which is recycled in the ratio of 9 vols./vol. air methane mixture. The mixture of fresh feed and recycle gas passes to an exchanger where it is preheated to 400°C. by the hot product gases from the reaction furnace. Nitric oxide, obtained by burning ammonia with air in the presence of a platinum catalyst, is added in the proportion of 0.08 vol. % of the fresh air methane feed. The resulting hot mixture of air, methane, recycle product gas and nitric oxide catalyst passes upward on the inside of empty reaction furnace tubes where conversion to formaldehyde takes place over the temperature range 400 to 600°C. The hot reaction gas from the furnace is cooled and passes to a water scrubber for formaldehyde removal. The formaldehyde-free scrubbed gas is recycled in large part, but a small proportion is used to fire the reaction furnace. The aqueous solution from the scrubber, containing 5 to 10% formaldehyde, is neutralised for removal of a minute amount of formic acid and then fractionated under pressure to yield a product containing 34 wt. % CH₂O, 3% MeOH and 63% H₂O.

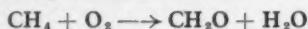
In a test run the methane consumption averaged 203.3 normal m.³/hr. and formaldehyde production 26.4 kgm./hr. on the basis of 100% concentration. This corresponds to 9.7% of theoretical yield. The process was operated at substantially atmospheric pressure.

T. K. Sherwood³² describes an improvement to this kind of method for producing formaldehyde, by mixing 3 to 5 parts natural gas with 7 to 5 parts of air and not more than 2% NO₂ by volume (based on total natural gas, air and NO₂), passing the mixture through a reactor at an emerging temperature of about 650°C., and immediately condensing a portion of the product by direct contact with cool formaldehyde solution. In this way decomposition of the formaldehyde, which would otherwise occur at the temperature at which the vaporised product issues from the reactor, is eliminated substantially.

R. P. Rossman³³ mentions some further modifications.

Hibernia process. During the war Dr. Karl Schmitt of Hibernia Bergwerksgesellschaft, A.G. developed a laboratory process for the production of formaldehyde by partial oxidation of methane by ozonised

oxygen in the presence of barium peroxide.^{31,34} The raw materials used were methane (about 70% from the separation of coke-oven gas) and Linde-Frankl oxygen (about 98%) which was ozonised to an ozone content of 0.5 to 2.0 vol. %. The reaction may be represented as:



Instead of oxygen air could be used, but this raised the cost of ozonisation considerably. On the other hand, superior formaldehyde yield was claimed for air oxidation.

Conditions. The reaction took place at 110 to 120°C. at atmospheric pressure, with an $\frac{\text{O}_3}{\text{CH}_4}$ ratio of $\frac{2}{3}$.

The catalyst consisted of alkaline earths (preferably Ba) activated with Ag₂O. Superior yields were claimed for a bed of comparatively large area and small thickness. The optimum gas velocity was found to be 4 to 10 m.³/hr. The temperature had to be well controlled, for the catalyst was not very active below 110°C., and above 120°C. oxidation tended to go beyond the formaldehyde stage.

It was necessary to dry the entering gases and for the H₂ content of the methane not to exceed 3%.

Yields and results. 350 gm. of CH₂O/m.³ CH₄ resulted per single pass, that is, about 26.4% of the theoretical. (Pure methane only yielded 5%.)

The catalyst behaved satisfactorily for about 1½ years.

Schmitt's own ozoniser was claimed to consume only $\frac{1}{4}$ to $\frac{1}{2}$ the current consumption of a standard Siemens ozoniser.

The exit gases were scrubbed with water and the aldehyde in the sorbate determined iodometrically.

5. MANUFACTURE OF ACETALDEHYDE

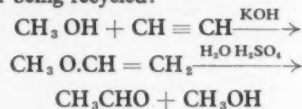
Acetaldehyde may be produced from the reaction of methanol with acetylene, or from acetylene hydration.

From methanol and acetylene

In 1945 it was stated that the Germans were quite likely to produce acetaldehyde on a large scale from methanol and acetylene. A report made in 1937 related to a projected plant for the manufacture of 5,100 tons/month *i.e.* 170 tons/day. This report claimed great advantages for this new process when compared with the usual (*e.g.* Schkopau) method depending upon the hydration of acetylene in the presence of mercury catalysts, both as regards purity of product and in actual operation. For example, blemishes and decomposition spots in sheets or films made from cellulose esters containing acetyl groups had been traced to mercury impurity in the acetic acid used. Acetic acid from acetaldehyde by the new route would obviously be superior for cellulose esterification purposes, since no mercury was used in the proposed new process.

It was claimed further that difficulties inseparably connected with the use of mercury and its recovery were obviated, and that in the new process no trouble was experienced with poisoning of catalyst. Even when using relatively impure acetylene, the caustic potash catalyst was able to take care of the impurities.

Description of process. The process was based on the reaction of acetylene with methanol under pressure to give vinyl methyl ether, which in turn was hydrolysed to give acetaldehyde and methanol, the latter being recycled:



Vinylation section. A flow diagram³⁵ illustrates the whole process of aldehyde formation.^{36,39}

The Vinylation reaction was carried out in a tower 15 m. high and 2 m. inside diameter. The tower, during operation, was filled with a 20% w/w. solution of caustic potash in methanol, the reaction temperature being 160°C., and the operating pressure 16 atm. Into the pressure tower was pumped continuously methanol containing a small quantity of dissolved caustic potash. The amount of the latter was not normally greater than 2% and was adjusted to maintain the concentration of caustic alkali in the tower at the 20% w. w. figure. The tower carried a gas circulation system by means of which an acetylene/nitrogen mixture was pumped in at 16 atm. pressure. Gas entering the tower had 35 to 40% V/V. acetylene, but emerged after deposition of the vinyl ether in the condensing system with only 10 to 15% acetylene. The fresh acetylene required was taken from a gasometer and was forced by a compressor into the circulation system.

The crude vinyl methyl ether eventually separated was run into storage tanks where it was held under 3 atm. pressure of nitrogen.

Hydrolysis and distillation section. The hydrolysis of vinyl methyl ether was conducted in an upright tower containing 0.25% sulphuric acid in water at 80 to 100°C. The operating pressure was 2.5 atm.

All the acetaldehyde with some methanol and water passed to a distillation column. From the column top passed acetaldehyde, which was condensed and run to storage. Water rendered slightly acid with sulphuric acid was fed to the column to prevent acetal formation. Aqueous methanol was run off from the base of the column when it was made weakly alkaline with caustic soda solution and then distilled. Any traces of aldehyde were resinified by the caustic alkali, and this was desirable since the methanol should be free from acetaldehyde.

Quantities involved. From a production of 170 tons/day of acetaldehyde,

ferric oxide and by cooling to -85°C . to remove higher acetylenes. The gas contained about 94 to 95% acetylene and traces of methyl acetylene. Diacetylene had to be removed from the gas completely, as it would reduce mercuric salts at once to metallic mercury.

A U.S. patent describes a vapour-phase reaction in steam which shows a greatly improved result.⁴⁰

A tower which may conveniently be built of acid-proof bricks, is filled with an absorbent siliceous material, such as porous tile, briquetted kieselguhr or kaolin, this material, in the form of lumps providing interstices for the passage of gases and vapours between it. The material is first saturated with a solution of a catalyst or with a liquid carrier in which the catalyst may be merely in suspension, to cause the catalyst to enter the pores and coat the surface of the carrier sufficiently so that it may be in a position to facilitate the reaction between the steam and acetylene. Mercuric sulphate or any suitable catalyst may be employed. However, it has been found in practice that superior results are obtained if instead of the usual catalyst employed in prior processes a catalyst which consists of a concentrated solution of mercuric sulphate in sulphuric acid containing a mixture of ferric, chromic, and ceric sulphate, together with titanium oxide, and manganese dioxide, is used.

Thus, assuming a suitable tower to be filled with a carrier mass of the type described, or with pumice stone, and this carrier to be saturated with a suitable catalyst, the mixture of acetylene, steam and air is passed through the mass starting at the bottom. The quantities of each of the reactants will preferably be in the proportion of 1 mole of C_2H_2 to $1\frac{1}{2}$ moles of H_2O as steam at 212°F . and $\frac{1}{4}$ to $\frac{1}{2}$ mole of contained oxygen in the air. The air is preferably preheated and is mixed with the steam in the preheated condition before introduction into the tower.

As this mixture of steam, acetylene and air passes up through the tower and contacts the catalyst, so acetaldehyde forms. By reason of the temperature employed, the acetaldehyde, as it is formed, will almost instantly be distilled out of the top of the tower where it can be condensed. The re-oxidation of the catalyst, by the oxygen in the air passed over it together with the steam and acetylene, will also take place almost immediately. The process may be practised continuously. It will be noted that the amount of steam used in the mixture of steam, acetylene and air is considerably more than the theoretical amount required to hydrate the acetylene to acetaldehyde. The reason for using an excess amount of steam is two-fold. Firstly, to be sure to have enough to effect substantially complete hydration of the acetylene, and secondly, to provide sufficient to prevent the mixture of air and acetylene from forming an explosive mixture.

It may be observed that the capital cost per throughput of the Shawinigan Plant⁴¹ for their acetylene hydration process in 1941 was still the lowest of any process for the production of acetaldehyde.²³

CONCLUSIONS

To produce the four chemicals acetone, methanol, formaldehyde and acetaldehyde ultimately from natural gas, the Sachsse or Controlled Oxidation process is to be recommended. Other processes described, which aim to produce acetylene, while being suitable for the manufacture of acetone and acetaldehyde, are unsuitable for methanol (and hence formaldehyde) production, and the economics of these processes would be affected by facilities to dispose of the large volumes of hydrogen produced.

When only formaldehyde is required (or, if it is not wished to produce formaldehyde from methanol) partial oxidation of methane under special conditions may be employed.

J. Roberts⁴² mentions that in Britain preliminary experiments of tapping methane from Point of Ayr Colliery showed that 500 cu. ft./min. or 720,000 cu. ft./day was produced, but that this figure fell to a fifth of this value or less after two years. Very much more methane however is available potentially from this colliery. Similar experiments at Cardowan Colliery have produced a methane flow of 500,000 cu. ft./day. These figures are quite insignificant when compared, for example, with the proposed utilisation of 65,000,000 cu. ft./day of natural gas in the controlled Oxidation process at the Carthage Hydrocol plant in Texas,¹⁸ but it is not out of the question that a plant to handle much smaller quantities of natural gas could be built, for a Calgary oil company, Canada, planned to erect a plant to handle 2,000,000 cu. ft. of natural gas/day,⁴³ while ammonia is produced in France by using about 883,000 cu. ft. of natural gas/day in a partial combustion process.⁴⁴

When more high quality methane becomes available from Britain's gas-rich gas coal seams, and if economic conditions dictate, it may be worth considering the erection of a small-scale plant using the Sachsse or Controlled Oxidation process to produce the chemicals which have been considered in this report. When considering the utilisation of our methane for the production of acetylene for chemical synthesis and other uses, engineers expressed the opinion that for the process to be economically feasible, a combination of three to four collieries producing not less than 1,000,000 cu. ft. of methane a day would be required.

The writer thanks the Director-General, Scientific Dept., National Coal Board, for providing the facilities for acquiring the above information.

Views expressed are purely personal unless otherwise indicated.

REFERENCES

(Numbered consecutively with those of Part 1)

- ²²B.I.O.S. Final Rept. No. 1053, Item 22.
- ²³Chem. & Ind., 1941, 60 (21), p. 338.
- ²⁴Canad. Chem. Proc. Ind., Sept., 1946, 30, (9), pp. 34-36.
- ²⁵Ind. Eng. Chem., 1948, 40, pp. 2230-2240.
- ²⁶B.I.O.S. Misc. Rept. No. 60.
- ²⁷Chem. Engrg., Feb., 1949, pp. 130-133.
- ²⁸Ibid., Jan., 1950, pp. 102-105.
- ²⁹Chemical Industries, Aug., 1947, pp. 214-217.
- ³⁰Chem. Engrg., Jan., 1949, pp. 93-94.
- ³¹F.I.A.T. Final Rept. No. 1085.
- ³²U.S.P. 2,412,014.
- ³³U.S.P. 2,467,993.
- ³⁴F.I.A.T. Final Rept. No. 608.
- ³⁵B.I.O.S. Final Rept. No. 370, Item 22.
- ³⁶B.I.O.S. Misc. Rept. No. 93.
- ³⁷Chem. & Engrg. News, 1949, 27, pp. 2062-2066.
- ³⁸B.P. 299,234.
- ³⁹B.I.O.S. Final Rept. No. 1049, Item 22.
- ⁴⁰U.S.P. 2,402,958.
- ⁴¹Chem. Met. Eng., 1933, 40, pp. 184-188.
- ⁴²Coll. Engrg., March, 1950, pp. 113-115.
- ⁴³Nat. Pet. News, 1946, 38 (24), p. 50.
- ⁴⁴Chim. et Industr., 1950, 63, pp. 492-493.

Australian process for refining sugar cane wax

A team of Australian scientists under the leadership of H. H. Hatt has developed a process of refining crude sugar cane wax. This process is claimed to produce a better wax than does conventional solvent extraction, but it is likely to be more expensive. Interest in sugar cane wax is high; it is thought that 60,000,000 lb. p.a. could be produced from Cuban mills alone.

The wax occurs as a thin white layer on the outside of the sugar cane. During milling it becomes entrained with the juice; after clarification with lime it is deposited on the filter press cake. The method used by the Australians involves demineralisation with hydrochloric acid, vacuum distillation for the removal of components of lower molecular weight and a chromic acid bleach.

As described in *Chemical Week* (1951, 69 (25), p. 23), demineralisation takes 24 hr. and is the time-limiting factor in the plant design. On the basis of treating 1,070 gal./day of wax, having an average mineral content of 5%, 900 gal. of 3.3% hydrochloric acid would be required. The wax is then sent to the distillation unit, where the lower-molecular weight components are removed under 1 mm. pressure at 300°C . In the last stage, the remaining wax is bleached at 110°C . with a mixture of chromic and sulphuric acids. It is washed with boiling sulphuric acid (30% w/v) and with water and then dried under low (200 mm.) vacuum. The Australians estimate an overall yield from crude to refined product—of 50%.

Although the process is more expensive, the Australians claim the wax produced is more flexible and can be modified to start a new series of waxes. Also, it is claimed, the process is capable of taking crude wax from different mills, and turning out a uniform product.

Chemical Engineering at the Cross-roads

PRESIDENTIAL ADDRESS TO THE INSTITUTION OF CHEMICAL ENGINEERS

By Sir Harold Hartley, K.C.V.O., C.B.E., M.C., D.C.L., F.R.S.

IN some Institutions it is the custom for the president to 'read himself in' with a presidential address on his induction; ours is, I venture to think, a better practice in which the president in his address can draw on his experience during his year of office. Certainly in my own case it has been a year of education and I have learnt much from my experience. I was able last September to return the welcome visit we had from Dr. Chilton, the president of the American Institute, in July, and to discuss many problems with our American colleagues. In March I went to Johannesburg for the inauguration of our South African branch and saw something of chemical engineering developments in the Union. During the year I have been to meetings of our home branches and of the Graduates' and Students' Section and I have visited a number of the chemical engineering schools in this country.

So you see, I am much better prepared to speak to you than I was when you did me the honour of making me your president. I told you then of my conviction of the increasing part chemical engineering is bound to take in the industrial life of Britain, and that conviction has only been strengthened and confirmed by all I have seen and heard.

The fourth primary technology

I have frequently had to explain to people what I understood by chemical engineering and why I was so insistent on its importance. I found that the simplest explanation was the historical sequence of events in the field of engineering. The civil engineer skilled in the technique of building structures, roads and bridges was first in the field, with an Institution founded in 1818. Next, with the evolution of the steam engine followed by power-driven machines, came the mechanical engineer. His Institution dates from 1847. And then with the advent of the dynamo and motor came the electrical engineer whose contributions in the distribution of power and in the field of communication by cable and wireless have changed so profoundly our way of life. His Institution goes back to 1871.

In each case a specialised technology gradually developed embodying both the results of experience and the application of science to the problems involved. Those are the first three primary technologies. A further 50-odd years saw the birth of our own Institution in 1922.

Until the 19th century man was dependent on very few chemical reactions, except



Sir Harold Hartley.

for combustion, metallurgy and fermentation, and his needs were met mainly by natural products. Then came the heavy chemical industry with acids, bases and fertilisers, and it was only in the second half of the 19th century that the beginnings of synthetic organic industry widened the scope of chemical industry with the production of dyes and pharmaceuticals.

The 20th century has seen a vast expansion of the chemical industry, with the rise of scientific methods of oil refining and of a great industry based on refinery gases and natural gas, together with the production of synthetic fibres and plastics. But of equal significance has been the invasion of chemical techniques into the processing of many natural products, food, wood, rubber and leather, and into the fermentation industries which they have revolutionised. The extractive industries have become chemical industries. Many of these developments have been on a huge engineering scale with throughputs of many tons a day, and continuous processes have replaced the older batch methods which had more in common with small-scale laboratory techniques.

As a result there has developed 'a distinct body of science which is fundamental and peculiar to chemical engineering. This involves principles, theories, procedures, methods and techniques fundamental to the majority of chemical engineering operations. While in some cases this body of science involves and utilises subject matter and principles common to other sciences, it modifies, extends, orients and combines these principles in a unique manner.' (J. G. Elgin.)

It is against this background that I have taken as the title of this address 'Chemical Engineering at the Crossroads.'

Signs and warnings

At the approach to crossroads one expects to find signs and warnings and there is no lack of them here—the Hankey report on the supply and demand for chemical engineers in Britain, the Dunsheath report of the productivity team that investigated the relations between universities and industry in the United States, the Cremer report of the Committee on Chemical Engineering Research and, finally, the recent discussion in the American Institute of Chemical Engineers on 'Whither, Chemical Engineering Science.'

The Dunsheath Committee were 'impressed by the extent courses in chemical engineering have been developed in America and by the extent to which these courses are regarded as meeting a widespread demand from various branches of American industry.' The number of courses in chemical engineering is exceeded only by those in civil, electrical and mechanical engineering and in 1949-50 the number of first degrees granted in chemical engineering was 4,529. 'Many Americans believe that these large numbers have had an important bearing on the rapid progress on industry in the United States.'

Alongside this sober statement or understatement of the facts, let me quote the words of Dr. Conant, the President of Harvard, in his address at the diamond jubilee meeting of the American Chemical Society last September:

'In 1902,' he said, 'chemical engineering had not developed as a profession. Today there is a great shortage of chemical engineers, in spite of the fact that more than 15,000 have been trained in the last five years. In short, the growth of the chemical profession within the lifetime of many of us here has been one of the amazing social phenomena of our times. It takes no crystal ball to show that this chemical revolution will affect the balance of the century. Whether the curve will continue to mount at the same rate of annual change is an open question, but that there will be vastly more members of this nation who were trained as chemists and chemical engineers in 2001 than there are now in 1951 seems to be one of the few certainties of the future. Notice I define the members of our profession in terms of their specialised education, not their employment. For one of the highly significant aspects of the development of chemistry in the last 100 years in all countries, but particularly here in the United States, is the way chemists have infiltrated into all sorts of positions in

scientific and industrial life. This process will continue, and one is safe in predicting that the work of the chemist in the United States has only just begun. The breadth of his scientific training and the strategic position of his science will make him one of the key figures in an urbanised, mechanised society dependent for its very life on the careful control of a multitude of chemical reactions.'

Now let us turn to the Hankey report to see what is the position here. From that report we learn that the annual output of chemical engineers from all sources in this country between 1950 and 1954 is estimated at 200. The comparison between this figure and the output in the United States speaks for itself. There is no need to emphasise the urgent need for a rapid increase in the number of chemical engineering courses at our universities and technical colleges, and an expansion in the size of existing courses where possible. The gap is far too large to be dealt with by any new technological university, and wherever engineering courses are now given, it seems only reasonable that undergraduates should have an opportunity to study chemical engineering if they so desire. I have been much impressed by the excellence of the courses in chemical engineering which already exist, and by the friendly and co-operative relations existing between the chemical engineers and the older schools of chemistry and engineering. Thus, in spite of the present disparity in numbers, I am optimistic for the future if the need to multiply and expand the courses in chemical engineering is recognised as most urgent both by the universities and by the University Grants Committee.

Training

Seventy-five years have passed since the first course in chemical engineering was given by George Davis in the Manchester School of Technology. Gradually the concept of unit operations from which manufacturing processes could be built up emerged as the best scheme of training for a chemical engineer, based on a knowledge of mathematics, chemistry and physics. With our increasing knowledge of the underlying principles of unit operations and with the ever-widening field for the chemical engineer, his education is tending to take new shape. Its form was the subject of our American colleagues' symposium last December on 'Whither, Chemical Engineering Science.' The general outcome of the discussion was to emphasise the need for the chemical engineer to be trained in the basic sciences and in the fundamental laws that are common to so many unit operations, rather than in the details of the unit operations themselves. Useful as it has been, the concept of unit operations must give way to a more fundamental approach in terms of which unit operations may be grouped with common underlying principles. With the many new applications of his techniques that

the chemical engineer may have to face, his training must aim at flexibility and adaptability of outlook and at a scientific rather than an empirical approach to new problems. The field to be covered is so wide, the problem so complex, that the training should aim at developing habits of mind that rely on scientific analysis, on experimental attack and on the availability of our accumulated scientific and engineering knowledge.

The way of the chemical engineer is not easy. Thermodynamics, chemical kinetics, the transfer of mass and energy, the concepts, of classical physics; all these he has to be able to apply to the engineering problems involved in the economical design of a plant in which some chemical or physical change is followed by the separation and the purification or the application of the products.

The Cremer report contrasts the two approaches to plant design: the analytical approach dependent on the functional analysis of the performance of existing plants, and the synthetic approach based on experimental investigations of the mechanism of each process and the laws governing it. With the many variables that enter into plant design, the training of a chemical engineer must teach him to make a judicious compromise between these two methods of approach and to select the fields where investigation would be of value. He must grow up in the challenging atmosphere of problems, with the opportunity to see the creative power of research in progress and, if possible, with the opportunity to learn something of the technique of investigation. This summarises roughly, I think, the findings of our American colleagues.

U.K. research facilities

The Cremer Committee were appointed to report on the position of chemical engineering research in this country. After reviewing the existing facilities and taking evidence from over a hundred firms and research associations, they reached the conclusion that 'existing facilities are inadequate for the purposes of the chemical and allied industries as a whole.'

Those research facilities fall into three groups: first, the laboratories of the great firms like Imperial Chemical Industries, Courtauld's, Distillers and Glaxo and of national establishments like Harwell, all of which together are vastly greater in resources than those of the other two groups; next, the laboratories of the chemical engineering schools of the universities and technical colleges; and, lastly, the laboratories of the plant designers and manufacturers which, with a few exceptions, are small and devoted to the companies' specialist fields. The need for more research of the synthetic fundamental type may be met by increasing research facilities at universities and by the growing numbers of chemical engineering schools, provided that funds are available. The Cremer Committee decided

however, that the analytical approach requires a central organisation specially adapted to this purpose, where under some co-operative scheme with industry the data from large-scale operations could be collected, analysed and quickly made available as a basis for plant design.

My own conviction is that the conclusions of the Cremer Committee do not go far enough in one respect. I am certain that the analysis of the results of plant operation will throw up gaps in our knowledge which can only be filled by experimental investigations on large-scale pilot plant, for which a laboratory will be needed. That to my mind is an essential constituent of the organisation that is needed in order to get the full constructive benefit from the analytical survey of plant operation which is proposed. Such a laboratory would be, too, a most valuable corollary to the more fundamental work in progress in university departments.

I will go further and say that, until we recover the initiative in chemical plant design and construction, we shall be forced to buy the 'know-how' at a high cost from abroad, and it will not be the latest 'know-how.' We can only regain that initiative by analytical and synthetic research, for the co-ordination and application of which the organisation recommended by the Cremer Committee is essential. Without it we shall not benefit from the results of our own scientific research, which in the past have so often been exploited abroad.

The only move towards implementing the recommendations of the report so far is the decision of the Department of Scientific and Industrial Research to publish a series of critical bibliographies on particular aspects of chemical engineering techniques. The first will deal with methods of industrial drying and the second with grinding methods and the dispersion of solid particles. The Institution has been asked to nominate a small expert panel to help in this work. This will certainly be a most useful contribution, but there remains the urgent need for the organisation envisaged in the Cremer report to collect, co-ordinate and publish the results of plant operations, together with a pilot-plant laboratory. Without this our design and construction industry will be seriously handicapped.

The future

With the emergence of chemical engineering as the fourth primary technology and its increasing part in the industrial life of the country, we have to take fresh bearings in research and education and decide what is needed in the future. What is the future of chemical engineering? What part is it destined to play in meeting the ever-growing needs of mankind with the increasing population of the world and the call for higher standards? Twenty years ago we were destroying surplus crops, today we are living in an age of shortages. The primary needs of the world are energy, food, metals and other raw materials.

How can they be met? What will be the contribution of chemical engineering?

Fuel and power

Let us start with energy—power and heat—for that is the key to the type of civilisation we have evolved, on which its continuance depends. As an index of its importance I showed in a paper on 'Limiting Factors to World Production' that before 1939 there was a close correlation between the energy consumption per head and the average real income in many countries.

With the inevitable gradual exhaustion of fossil fuels, great hopes are based on the use of nuclear energy in the future. Whether these hopes are likely to be fulfilled I will not venture to predict, but one thing is certain, their fulfilment will depend largely on chemical engineering.

The advent of atomic energy has introduced new features to the industrial scene. Many of the materials required were laboratory curiosities before the war; some were unknown. The production of materials for the construction of reactors, the production of fissile 'fuel,' the reprocessing of the spent 'fuel' and the safe disposal of fission products all involve the development of fresh chemical engineering processes and the design and operation of new forms of plant. The design of some of this plant is based on previous experience, but much is quite new and is giving plenty of scope for ingenuity and initiative. Atomic energy has, for example, given a fresh meaning to remote control. War-time achievements were made without counting the cost, but the improvement of the economies of the processes to the point where atomic energy can compete on level terms with conventional sources, provides a real challenge to the chemical engineer. Not only must he design safely for very high efficiencies in yield and quality, but he must also design economically because of the high capital costs of plant and buildings.

Solar radiation is an even more potent and ever-present source of energy. It is the basis of existence of living organisms, but we make so little use of it today. With the depletion of fossil fuels it is inevitable that the day will come when man must harness the sun's rays. How and when that will be done will depend on advancing knowledge. Whether it will come through controlled photosynthesis, through photo-electricity or through fuel cells free from the inevitable limitations of the thermodynamics of the heat cycle, or other means, no one can say, but when it does I venture to predict that the techniques of chemical engineering will play their part.

Turning now to the more conventional methods of utilising energy, I take first steam power stations. There again so many of the problems on which efficiency and availability of the boiler will depend involve chemical engineering techniques—combustion, radiation, heat exchange,

boiler deposits, the treatment of effluents, cooling towers, water treatment and corrosion. All of them becoming more urgent with higher steam conditions.

There is no need to emphasise what chemical engineering has already done to raise the efficiency of use of the fossil fuels—coal, oil and natural gas. Indeed, the great developments of oil refining have gone hand in hand with the science of the chemical engineer, to whom it owes the new technique of fluidisation, the influence of which is now being felt in many other industries. There is, too, the huge new chemical industry based on refinery gases and natural gas. Much the same is true of the processing and carbonisation of coal. Indeed, apart from the need for smokeless fuels and oven coke, its future may lie in total gasification carried out in part underground, together with the possibilities of synthesising liquid fuels where conditions are favourable. Thus in the field of energy the chemical engineer will be an indispensable partner in the team.

Metals

Leaving food aside for a moment and turning to metals, two facts emerged very clearly at the United Nations' conference on resources at Lake Success in 1949: first, the growing consumption of metals with the spread of industrialisation and, second, our increasing dependence on lower-grade ores. Known reserves of non-ferrous metals will provide for, say, half a century at our present rate of consumption, pointing in the long run to a steel and light alloy economy with non-ferrous metals reserved for essential purposes. Chemical engineering has already contributed much to the ore dressing of low-grade ores, and to the extraction of metal from them. Take, for example, the extraction of gold from ores containing not more than 1 dwt. per ton, or the extraction of magnesium from sea water containing about one part per thousand of the metal, made possible by accurate chemical control of the conditions in vast volumes of water, and the adaptation of known techniques. Another example is the production of extremely pure zinc by fractional distillation as a result of the application of chemical engineering principles in a field previously covered by crude empiricism.

It would be easy to multiply these instances of the value of chemical engineering techniques in metallurgy and there is no need to dwell on their contribution to the heavy chemical industry. The fixation of atmospheric nitrogen is but one example.

Food and raw materials

I come now to the products for which we have to rely mainly on living organisms—food and raw materials. In order to get the problem into its proper perspective, some years ago I made a study which showed that on a value basis 87% of farm and forest products were used as food and

13% in industry. This represents about one-third of industry's raw materials, the remaining two-thirds coming from non-living sources. Zimmerman arrived independently at much the same figures, from which it follows that the feeding of men and animals consumes about 70% of all raw materials on a value basis and industry consumes the rest.

The 20th century has seen great changes in the nature and the use of raw materials in industry, in which chemical engineering has played its part. One major trend has been the processing of natural materials like rubber and leather as their chemical and physical nature has been better understood. The scientific control of their manufacture has resulted in improved quality and greater uniformity of the products. Another striking development in this field has been the recovery of valuable by-products during the preparation of natural materials and the processing of the waste products of agriculture and forestry in which our own Colonial Development Corporation has taken its place alongside the four great regional laboratories in the United States dedicated to these studies. This opens up a new field for the co-operation of the organic chemist, the plant geneticist and the chemical engineer. I could quote many examples. The steep liquor in which maize has been soaked prior to wet milling is an excellent nutrient, together with lactose, for the production of penicillin, and the yields increased rapidly when this was discovered. A valuable wax can be obtained as a by-product in sugar refining. Furfural, made on an engineering scale from maize cobs and oat husks, is used for many purposes, most recently as the starting material for making nylon.

Another major trend has been the rapid development of synthetic materials, in some cases in competition with natural materials, in others in partnership with them. These synthetics are all carbon compounds manufactured from coal, oil or natural gas or from natural materials such as cellulose or proteins. Fibres and plastics are two of the main developments. Synthetic fibres—rayon, viscose, nylon, Ardil and Terylene—often spun with wool or cotton, help to meet the world's ever-growing need of textiles.

The field for plastics is widening daily. One of the newcomers, polystyrene, has already reached a production of over 250,000 tons a year. Incorporated with synthetic rubber it replaced leather in 1950 in roughly half of the 500,000,000 pairs of shoes made in the United States alone. I give these figures to indicate the engineering scale of the plants in which these new materials are produced in continuous processes. Catalysis plays such a vital part in so many of these plants that one asks the question: 'Are there limits to the use of man-made catalysts?'

Some 20 years ago I was talking to Carl Bosch, the chairman of the I.G., about the

future of tropical agriculture. He told me something that Steinmetz, the genius of Schenectady, had said to him which has a bearing on this question. Steinmetz had said, 'Bosch, I know you can make indigo cheaper than God; some day you may make rubber cheaper than God, but you will never make cellulose cheaper than God.'

Let us see how this remarkable prophecy stands today in the light of our present knowledge. We can make a relatively small and simple molecule like indigo economically. As the complexity increases, as in penicillin, nature wins; though sometimes by taking advantage of a cheap natural product, like citral from lemon grass used as an intermediate in the synthesis of vitamin A, we can compete with nature.

We can manufacture simple molecules like butadiene and polymerise them to give synthetic rubber, or we can take mixtures of simple molecules to give copolymers, but these long chains are built up by the regular repetition of simple units. Now life is dependent upon much more complex molecules, proteins and polysaccharides, the result of the long series of adjustments in the evolution of animal life. For our food we are dependent directly or indirectly on the products of photosynthesis, the basis of the living process in which solar energy is used by nature's catalysts to convert carbon dioxide and water into carbohydrates by a complex process which we have never simulated in the laboratory. That process has been responsible for our stores of fossil fuels and we rely on it today for the food we get from plants and animals. I hesitate to say that anything may prove impossible, but my conviction is that the man-made catalyst will never compete with the living cell in producing those complex molecules which its enzyme systems build so accurately and cleanly by the template methods in successive steps which they probably employ.

You may think that I have strayed far from my subject, but in view of all this I return to ask how chemical engineering is to play its part in future in helping to meet the world's needs for these complex molecules. Clearly not by competing with nature, but by a more intimate partnership with her.

What forms will that partnership take?

First, the help that agriculture will derive from improved fertilisers, from new weed-killers, fungicides and insecticides, from new antibiotics to eliminate disease in man, and animals and plants and possibly from substances which modify the soil structure to give those optimum conditions on which the crop yield so much depends.

Next there is the development on which I have already touched, the processing of food products to up-grade and preserve them and facilitate their transport, together with the processing of farm residues, thus 'converting a disposal problem into a disposable income.'

Bio-chemical engineering

But lastly and of most significance for the future is the partnership in what is properly called bio-chemical engineering, a partnership in the activities of living cells working in man-made environment. I use the hyphen deliberately because it is not a new form of chemical engineering but the adaptation of its techniques to meet the conditions imposed by the living organism.

Fermentation is the oldest of chemical industries and now, with our fresh knowledge of the habits of bacteria and other unicellular organisms and plants, it is taking on a new guise as we adapt it to yield a great number of the organic substances that we need. Most striking is the use of moulds to produce on an engineering scale those powerful new antibiotics, penicillin, streptomycin and aureomycin, that have opened a new chapter in man's defence against disease. Success in producing these antibiotics on a large scale by the growth of submerged cultures of moulds is dependent on the accurate control of their environment; temperature concentrations of nutrients and oxygen, and the pH must all be regulated. Then the maintenance of sterile conditions to prevent the destruction of the cultures by bacteriophages has involved many new engineering problems. Existing techniques have been adapted to the task of extracting the small concentrations of these delicate complex molecules from the culture media and to their purification. Penicillin, for example, after filtration of the mould, is concentrated by solvent extraction from the clear liquid with butyl alcohol, using centrifugal counter-current extractors. It is then crystallised under vacuum after the water has been removed from the butyl alcohol solution by azeotropic distillation.

Streptomycin is now extracted by absorption on a carboxylic base exchange resin from which it is eluted by dilute acid. After neutralisation by passage through an anion exchange resin, the purified streptomycin is isolated as its sulphate or as the calcium chloride double salt.

The phenomenal rise in production of these antibiotics, most of which were unknown ten years ago, has been made possible by most delicate feats of chemical engineering.

In these, as in other fields of bacteria fermentation, great progress is being made in finding new strains of micro-organisms in nature, in making artificially mutants with new characteristics by means of x-ray or ultra-violet radiation, and in reinforcing their metabolic efficiency by changes in their chemical environment, thus helping them to produce the substances we need. For simpler substances like alcohol, chemical synthesis and micro-organisms will always be in competition, but in the long run micro-organisms will have the advantage of being able to break down the complex products of plant growth.

So far I have been speaking of the by-

products of the metabolism of micro-organisms which derive their supplies of free energy necessary to maintain their living processes from the plant and animal nutrients with which they are fed. But there are other micro-organisms containing chlorophyll which are able to use solar radiation when suspended in solutions containing carbon dioxide, nitrates and other mineral salts, in order to synthesise carbohydrates and proteins. There is thus a possibility of using them to meet the need for increased food supplies. Under favourable conditions the unicellular alga, *Chlorella*, can make use of 30% of the incident light while vegetation only uses about 1%. It may therefore be feasible to raise considerably the output of food from a given area. In the earlier stages of its growth *Chlorella* produces predominantly proteins, in its later stages fats. Investigations are now in progress to see whether it may be possible to use such simple organisms on an industrial scale to produce foodstuffs economically.*

This work is in its infancy. There are many biological engineering problems to be solved, but it may well point to a new biochemical partnership with nature.

In a survey of this nature, whether one looks at the immediate or the more distant future, one is driven to the conclusion that the world must depend more and more on chemical techniques in order to utilise to the full the limited resources of our planet so as to meet the needs of its growing population. To do this the chemical engineer is bound to play an increasing part in partnership with the older branches of engineering. In any project he will be the liaison between the research laboratory and the team of engineers, the co-ordinator of their contributions.

The thought running through my mind, in the light of all this, is the seriousness of our responsibilities as members of this Institution—our responsibility as the qualifying body for maintaining and enhancing the traditions of the profession of chemical engineers, our responsibility for encouraging schools of chemical engineering and for making public the urgent need to increase the output of chemical engineers and, finally, our responsibility to provide opportunities for the discussion and publication of contributions to knowledge in our field. The success of our trusteeship will depend on the efforts and interest of individual members, and the best augury for the future I see in the strength of our Graduates' and Students' Section.

It was largely by engineering skill and invention that Britain won its place among the nations during the Industrial Revolution, and it is in these same fields, in this second Elizabethan age, that our strength still lies. Chemical engineering, the newcomer, is not competitive with the older branches of engineering but complementary to them.

*See INTERNATIONAL CHEMICAL ENGINEERING, March 1952, p. 133.

Treatment of Waste Waters from the Manufacture of Penicillin

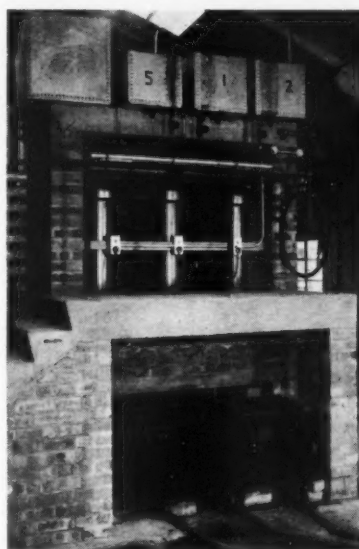
By G. E. Eden, B.Sc., A.R.I.C., and G. F. Lowden, B.Sc.

The highly polluting nature of the waste waters arising from penicillin manufacture poses a very difficult problem in effluent disposal. Originally an evaporation method was proposed, but subsequent methods of treatment have been entirely biological. Here is a detailed account of an investigation to find the best method of disposing of penicillin effluent at a factory in the north of England.

PENICILLIN is produced by a process of fermentation in which a suitable strain of *Penicillium* is grown in a medium containing organic and inorganic nutrient substances. When the maximum concentration of penicillin is attained, the mould is filtered off and the penicillin is isolated from the medium by solvent extraction or by adsorption on activated carbon. The residual aqueous solution contains a high concentration of organic matter and may, under certain conditions, support growth of many types of micro-organisms; it is therefore highly polluting in character and its disposal presented a problem even in the early days when penicillin was manufactured by 'surface culture' in small flasks. With the advent of the 'deep culture' process, in which batches of several thousand gallons are fermented, the production of penicillin greatly increased, as did the resulting volume of waste waters.

Various methods for the treatment of these waste waters have been discussed, chiefly in American journals. One of the first methods described was that of Knoedler and Babcock,¹ who evaporated to dryness a mixture of mould and spent metabolite. Later methods of treatment have been entirely biological; for instance, Rudolfs and Guercio² obtained well-purified effluents by filtration through sand. Hilgart³ described the operation of a plant for the treatment of penicillin and streptomycin waste waters using percolating filters. Heukelekian⁴ recommended preliminary treatment by aeration in the presence of an inoculum of settled tank effluent ('aeration with non-flocculent growths') followed by biological filtration. A comprehensive investigation of the relative efficiency of various biological methods has recently been reported by Muss.⁵

The present paper contains a report of experimental work carried out in 1946 (before the publication of the papers referred to above), with the object of finding a method of disposal of the effluent from a factory in the north of England. Unfortunately it was necessary to discontinue the investigation at a comparatively early stage, and for this and other reasons it was not entirely satisfactory. It is felt, however, that the results obtained are of some interest and indicate the direction in



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Fig. 1. Experimental percolating filters of the type used for treatment of spent metabolite.

which a solution of this particular problem might be found.

The problem

The factory was constructed under the auspices of the Ministry of Supply and was later transferred to the ownership of a firm of pharmaceutical manufacturers. The site did not provide any convenient means of disposing of the effluent. Sewage from the local population of about 5,500 persons was treated at a small works by sedimentation and biological oxidation in percolating filters before discharge to a river; preliminary calculations indicated that the discharge to the works of all the factory effluent would increase by two or three times the total quantity of polluting matter reaching the works. Since most of the polluting matter in the factory effluent would probably not be removed by sedimentation, the proportional increase in the amount of organic matter to be dealt with by the filters would be greater than this. Though the sewage works was operating efficiently, it was clear that it could not deal with an increased load of this magnitude without considerable modification. Local conditions also rendered

impractical certain other methods of disposal, such as percolation into the soil or direct discharge to the river.

To enable production to proceed, arrangements were made for the spent metabolite to be transported by road tanker to the coast for discharge through a sewer into the sea. This was clearly an expensive and rather inconvenient method of disposal.

Programme of investigations

It was desired to obtain information on the three following points:

(1) The composition of the waste waters likely to be discharged from the factory.

(2) The volume of waste waters that could be accepted by the existing sewage-disposal works without detriment to the quality of the effluent, and the modifications that would be required to enable the works to deal with the whole of the factory effluent.

(3) Methods which might be applied at the factory to reduce the polluting strength of the effluent sufficiently to permit discharge to the existing sewage-disposal works or to the river. It was recognised, however, that the management of the factory would prefer that the liquor should be treated at the sewage works, and this had an important bearing on the planning of the investigation.

Waste waters discharged by the factory

At the particular factory the 'deep-culture' process was employed, and penicillin was isolated from the metabolite by extraction with amyl acetate after acidification with phosphoric acid to a carefully controlled pH value. The aqueous phase remaining after extraction was neutralised, usually with caustic soda, and passed through a stripping column in which the solvent was distilled off. The term 'spent metabolite' is used subsequently in this paper to denote spent metabolite which had been neutralised and stripped in this way. On a few occasions lime was used as the neutralising agent, but as large volumes of sludge were produced the use of caustic soda was preferred. There was little difference in the polluting strength of spent metabolite neutralised with lime as compared with that of similar samples neutralised with caustic soda. The use of

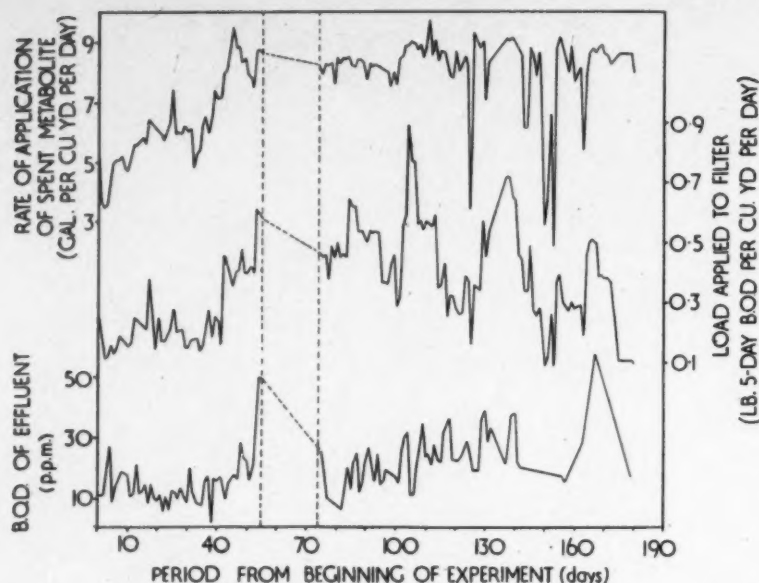


Fig. 2. Treatment of undiluted spent metabolite by biological filtration with recirculation. Average B.O.D. of spent metabolite, 4,720 p.p.m.

caustic soda resulted, of course, in a liquid containing a high concentration of sodium phosphates.

During the period of the investigation many samples of spent metabolite were examined and the composition was found to vary widely from time to time, as a result, no doubt, of alterations in the methods of production in the factory. Mean results are presented in Table 1. No figures for pH value are given, partly

Table 1. Average results of analysis of samples of spent metabolite after neutralisation and removal of amyl acetate.

	Mean value (parts per million)	Number of determinations
Biochemical oxygen demand in five days at 18.3°C.	4,910	203
Oxygen absorbed from acid N/80 permanganate in 4 hr. at 26.7°C.	2,930	204
Total solids dried at 105°C.*	26,800	200
Loss on ignition of total solids	10,800	200
Reducing sugars (as glucose)	416	38
Total sugars (as glucose)	913	56
Ammonia (as N)	91	63
Nitrite (as N)	28	21
Nitrate (as N)	1.9	37

*A large proportion of the total solids consisted of soluble phosphates formed as a result of the acidification and subsequent neutralisation of the spent metabolite.

because a figure derived from the mean of the hydrogen-ion concentrations is of doubtful value, but chiefly because the pH value depended largely upon the accuracy with which neutralisation was carried out. The pH value was usually in the range

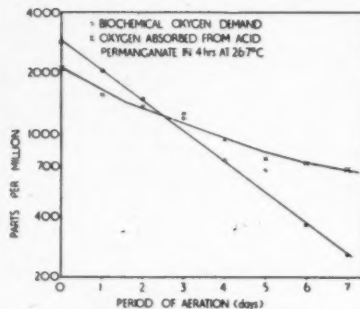


Fig. 3. Effect of prolonged aeration of a mixture of 100 ml. settled sewage and 900 ml. spent metabolite. From 54th to 74th day no spent metabolite was available. The filter was maintained on diluted corn steep liquor.

6 to 7. The volume of spent metabolite which would be discharged daily when the factory was in full production was variously estimated to be 10,000 to 25,000 gal., and

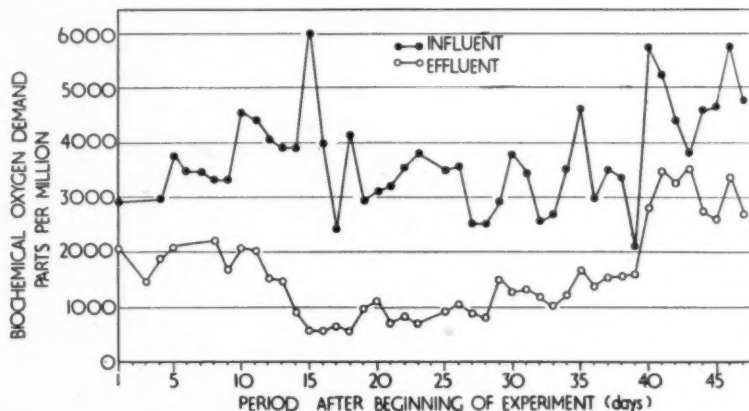


Fig. 4. Effect on biochemical oxygen demand of aeration of undiluted spent metabolite. Total volume, 120 litres; half the settled liquor was withdrawn each day.

its content of polluting matter as measured by the biochemical oxygen demand (B.O.D.) in five days would be equivalent to that of the crude domestic sewage from a population of 4,000 to 10,000 persons.

Apart from spent metabolite a small quantity of effluent, consisting mainly of floor washings and similar liquids, was discharged to the sewers through a balancing tank. Investigation showed that the population equivalent of this effluent was about 500 persons and that it did not therefore impose a very large additional load on the sewage works. Domestic sewage from the factory was discharged direct to the sewers.

Treatment of diluted spent metabolite in small percolating filters

In preliminary experiments spent metabolite, diluted with the local tap water to a biochemical oxygen demand of about 275 p.p.m., was treated by single biological filtration in four laboratory-scale percolating filters at rates of 60, 70, 80 and 90 gal./cu.yd./day. The filters, of the type shown in Fig. 1, were filled with medium obtained from the filters at the local sewage-disposal works; the presence of the necessary biological film was ensured by passing diluted corn steep liquor through the filters for a period of a few weeks. Results of operation of these filters, summarised in Table 2, indicated that satisfactory effluents were produced at each rate of flow. After operation for 92 days at the two higher rates and for 147 days at the lower rates, biological film had grown in each filter to such an extent that severe ponding occurred and the experiments were discontinued. In large-scale operation it is probable that ponding would be much less severe because of the normal functioning of fly larvae and other scouring organisms; few such organisms were present in the laboratory-scale filters. The experiments showed, however, that diluted spent metabolite could be readily treated by biological filtration at normal loadings to yield an effluent of satisfactory quality.

Continuous filtration of undiluted spent metabolite with recirculation of effluent

Even on a large scale ponding may result if a percolating filter is overloaded. One of the ways of increasing the load which a percolating filter can handle is to dilute the liquid applied to it with recirculated filter effluent.⁶ The following experiment was therefore undertaken to determine whether the efficiency of a percolating filter treatment spent metabolite could be improved in this way. It was decided to attempt to treat undiluted metabolite, using only its own effluent for dilution before application to the filter, because any adverse effect resulting from the accumulation of inorganic salts in the effluent would then become more readily apparent.

Furthermore, this procedure, if successful, would provide a simple method for the treatment of metabolite at the factory, should this become necessary.

Spent metabolite was applied to the filter once every 4 min. by the rotation of a synchronous two-way valve which alternately filled and emptied a pipette adjusted to deliver the required volume. Settled effluent was recirculated by a simple air ejector device, the air supply of which was controlled by a second two-way valve synchronised with the first. The relative phases of the two valves were so arranged that the dose of spent metabolite entered the mixing vessel just before the recirculated effluent; this was discharged with a considerable velocity to ensure that metabolite and effluent were efficiently mixed. The volume of the mixing vessel was such that the intermittent siphon did not begin to discharge until nearly all the dose of effluent had been delivered.

Results of this experiment are shown graphically in Fig. 2. Because of the wide variation in the strength of the spent metabolite the load applied to the filter also varied considerably. It is clear, however, that at B.O.D. loadings of about 0.5 lb./cu.yd./day it was possible to produce an effluent with a biochemical oxygen demand of about 30 p.p.m.; this represents a reduction in B.O.D. of over 99%. It was also observed that the value for oxygen absorbed from acid permanganate by the effluent was very high—of the order of 250 p.p.m. This was thought to be due to the presence in the effluent of humus-like materials.

Preliminary treatment of spent metabolite by aeration

The reduction in the polluting strength of spent metabolite by aeration was investigated with a view to the possible development of a simple method of treatment which could be adopted at the factory. Preliminary results were promising; for instance, Fig. 3 shows graphically the effect of aerating for several days a mixture of 900 ml. of spent metabolite with 100 ml. of settled sewage. Though it appeared

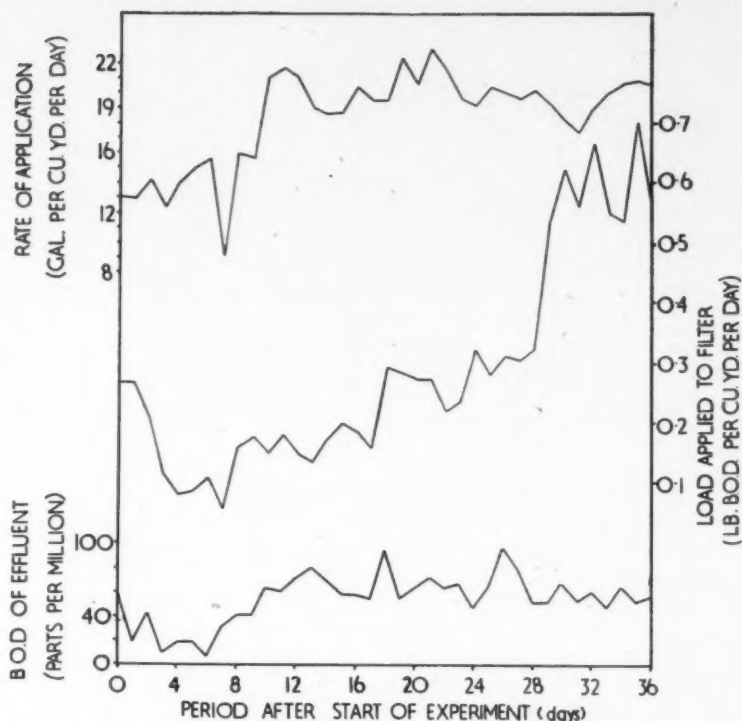


Fig. 5. Further purification of effluent resulting from aeration of spent metabolite, by treatment in a percolating filter with recirculation of part of the effluent.

unlikely that a completely purified effluent could be produced in this way, sufficient purification might be obtained to permit discharge to the sewer without imposing an undue additional load on the sewage-treatment processes.

In a second experiment, using somewhat larger volumes, 120 l. of spent metabolite, inoculated with 0.5 l. of settled sewage, were aerated in a tank fitted with an air diffusion plate 1 ft. square. The rate of aeration at the beginning of the experiment was the maximum which could be employed without excessive frothing. Each day, after the contents of the tank had been allowed to stand quiescent for 1 hr., 60 l. of supernatant were siphoned off and were replaced by an equal volume of fresh spent metabolite; aeration was then resumed. Results of analysis of samples of spent broth and of treated effluent are shown in Fig. 4. A considerable degree of purification was usually obtained. The deterioration in the quality of the effluent towards the end of the period of the experiment was attributed to progressive blocking of the

diffusion plate by biological growths and to numerous failures in the supply of compressed air. The proportion of sludge produced during this experiment remained less than 4% by volume after settling for 1 hr. and the supernatant liquid was invariably cloudy.

Further treatment of aeration-tank effluent

An attempt was made to reduce further the polluting strength of liquor, which had first been treated by aeration, by a process of biological filtration with recirculation of effluent. The rate of recirculation was again 200 gal./cu.yd./day. Results are shown graphically in Fig. 5. It was found that for B.O.D. loadings of from 0.15 to 0.6 lb./cu.yd./day the biochemical oxygen demand of the effluent averaged about 60 p.p.m. By comparison with the results of treatment of spent metabolite in a similar way this would seem to indicate that for some reason it is more difficult to produce an effluent of high quality after preliminary treatment of the spent metabolite by aeration. Never-

Table 2. Average results of treatment of diluted spent metabolite by passage through laboratory-scale percolating filters, 9 in. in diameter and 4 ft. 10 in. deep.

Filter No.	Rate of application (gal./cu.yd./day)	Duration of experiment (days)	Oxygen absorbed from N/80 acid permanganate in 4 hr. at 26.7° C. (p.p.m.)		Biochemical oxygen demand in five days at 18.3° C. (p.p.m.)	
			Influent	Effluent	Influent	Effluent
1	58.0	147	142	29.1	275	7.6
2	68.7	147	142	30.5	275	5.6
3	78.3	92	142	30.2	275	10.3
4	89.2	92	142	30.0	275	9.4

theless the efficiency of removal of B.O.D. in the filter was of the order of 96 to 98%.

Controlled discharge of spent metabolite to the sewers

The local sewage, which was predominantly domestic in character, was treated by the normal processes of screening, sedimentation, and biological filtration. The primary sedimentation tank had a retention period of 7 hr. at dry-weather flow. There were three percolating filters, with a total capacity of 2,385 cu. yd., contained within a common surrounding wall. Filter effluent was settled in two small humus tanks before discharge to the river. The arrangement of the filters rendered it impossible to isolate one filter and made it necessary to observe the effect of metabolite on the filters as a group with no control experiment. Approximate measurements of the rate of flow through the works were made at a submerged weir situated in a channel between the detritus tank and the primary sedimentation tank. Considerable variations in the rate of flow occurred from time to time, and it is believed that this was largely caused by infiltration of ground water into the sewers.

During the period of experimental work already described, many samples of sewage and of effluent were taken from the local sewage works to determine the general state of efficiency of the treatment processes. The effluent as a rule was of good quality; on those occasions when effluents of poor quality were discharged it was found that most of the B.O.D. was contributed by suspended matter which could be removed by a short period of sedimentation or by filtration through a coarse paper. The production of such effluents was therefore attributed to inefficient sedimentation in the humus tanks and would presumably be accentuated by any increase in the rate of flow of sewage through the works.

It was also observed that the greater part of the polluting load reached the works during the period from 10 a.m. to 10 p.m. and that there was a tendency for bad effluents to be produced at the time of maximum loading of the filters (Fig. 6). Arrangements were therefore made, with the approval of the local authority and of the Ministry of Health, for a controlled discharge of 3,000 gal. of spent metabolite to take place nightly at a steady rate between the hours of 6 p.m. and 9 a.m. In this way it was hoped to dispose of an appreciable quantity of spent metabolite by applying it to the filters at a time when they were comparatively lightly loaded. In Fig. 6 results are given for the load on the filters and the biochemical oxygen demand of samples of settled sewage and settled final effluent taken over typical periods of 24 hr. On comparing the two sets of curves it will be seen that as a result of the discharge of spent metabolite the biochemical oxygen demands of the crude sewage and settled sewage did not

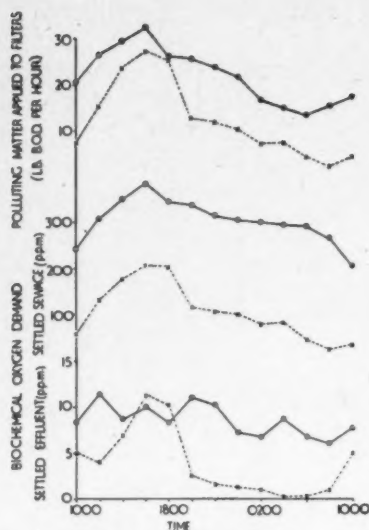


Fig. 6. Load on filters and biochemical oxygen demand of sewage and effluents at the sewage disposal works 10 a.m., Thursday, to 10 a.m., Friday . . . no metabolite discharged—about 3,000 gal. of spent metabolite with a B.O.D. of 4,690 p.p.m. were discharged between 6 p.m. and 9 a.m.

fall to such low values during the night and that of the settled effluent was nearly constant over the period of 24 hr.

Examination of samples of effluent over a more prolonged period during which the controlled discharge of metabolite was continued showed no deterioration which could be definitely attributed to the metabolite. It was felt, however, that the filters were by then operating nearly at their full capacity and that it would be unwise to discharge a much greater quantity of the liquor.

Other considerations unfortunately made it impossible to continue the experimental work to obtain a more accurate estimate of the effect of discharging a slightly larger volume of metabolite. From the results obtained in the laboratory it would appear that a percolating filter with recirculation of effluent should be able to treat efficiently a volume of spent metabolite equivalent to a B.O.D. loading of about 0.4 lb./cu.yd./day. It is known that a similar load of domestic sewage may also be treated satisfactorily in this way. It is therefore reasonable to assume that for a mixture of spent metabolite and sewage the same loading may be employed. If recirculation of effluent were adopted at the works the filters should be able to deal with $2,385 \times 0.4 = 944$ lb. B.O.D. per day. The normal load of domestic sewage is 311 lb. B.O.D. per day. This means that 633 lb. B.O.D. of metabolite, or 12,000 gal. having a B.O.D. of 5,000 p.p.m., could be treated per day.

Space was available at the works for a fourth filter similar to the three then in operation. Installation of this filter together with recirculation would increase the amount of spent metabolite which could be treated at the works to 19,000

gal./day. Recirculation would involve, of course, not only the installation of pumps and pipes but also of additional humus tanks to deal with the increased flow of filter effluent.

The sewage-disposal work is now being modified so that large-scale experiments can be carried out on the treatment of spent metabolite to determine what volume of the liquor can be treated continuously. The spent metabolite will be taken to the works by road tanker, stored in a balancing tank, and admitted to the sewage at the discretion of the sewage-works manager. If necessary, the mixture of liquor and sewage will be diluted by recirculating part of the settled effluent from the filters. To make these experiments possible a balancing tank and additional gauging and pumping equipment are being installed and the humus tanks and distributors are being enlarged; it is expected that the plant will be ready for use in 1952.

Acknowledgments

This investigation was made as part of the programme of the Water Pollution Research Board of the Department of Scientific and Industrial Research, and the paper is published by permission of the department.

REFERENCES

- ¹E. L. Knoedler and S. H. Babcock, *Industr. Engng. Chem.*, 1947, 39, p. 578.
- ²W. Rudolfs and V. D. Guercio, *Water and Sewage Wks.*, 1947, 94, p. 349.
- ³A. A. Hilgart, *Sewage and Industr. Wastes*, 1950, 22, p. 207.
- ⁴H. Hebblekian, *Industr. Engng. Chem.*, 1949, 41, p. 1535.
- ⁵D. L. Muss, *Sewage and Industr. Wastes*, 1951, 23, p. 486.
- ⁶E. V. Mills, *J. and Proc. Inst. Sewage Purif.*, 1945, Pt. 2, p. 94.

New standard

Pipeline welding. 'Oxyacetylene Welding of High-Temperature and High-Pressure Pipelines' is the title of a new British standard which is the first of a series being prepared for the welding of pipelines and covers pipelines for service conditions in which the pressure exceeds 250 p.s.i. and/or the temperature exceeds 425° F. (220° C.). The standard lays down the conditions for shop and site welding of joints in such steel pipelines and fittings up to and including 20 in. diameter and is divided into four parts.

Part 1 defines the parent metals and specifies the types of filler rods, welding technique, general precautions and qualifying tests for welders. Part 2 deals with butt joints and specifies the method of preparation and requirements for the completed welds. This section covers not only plain butt welds, but also flanges and bends, both gusseted and cut-and-shut. Part 3, for branches, includes details of preparations for the set-on and set-in types. Sleeve welds are covered in Part 4. This standard (B.S. 1821: 1952) costs 6s., post free.

Copies may be obtained from the British Standards Institution.

NEW PHOSPHATE STORAGE SYSTEM



Left: Aerial view of the rotary stacker and semi-circular storage pile in the foreground. The rotary stacker swings over a semi-circular storage pile of various grades of rock. Rock is dropped from the top of the stacker on to the appropriate section of the pile below. **Right:** Directly under the semi-circular storage pile is a reinforced concrete tunnel. Rock is blended by opening overhead doors (each directly under a certain grade of rock) permitting the desired grades to fall on to conveyor belts. The belts carry the blended rock to two transfer conveyors which in turn carry the rock out of the tunnel to another dual conveyor system leading to the dry plant.

THE first storage system of its kind in the phosphate industry was installed recently by the American Cyanamid Co. at its plant in Brewster, Florida.

Introduction of the new system, which includes a rotary stacker conveyor and underground tunnels for blending, brings added storage capacity, more accurate blending and more efficient operation of the storage facilities and of the mines themselves.

With the new system in operation, rock from Cyanamid's two nearby phosphate mines arrives at the Brewster 'dry' plant in hopper-bottom cars which empty directly into a track hopper. From the track hopper the rock is fed at 600 tons/hr. (currently being stepped up to 800 tons/hr.) on to a 36-in.-wide conveyor belt running up an 80-ft.-high stacker which pivots over a wide semicircle. This rotation is controlled from the track hopper building.

Under the stacker is a semi-circular storage pile consisting of various grades of rock at different points. The rock is dropped from the top of the stacker on to the appropriate part of the pile below.

Directly under the different grades of rock in the storage pile are evenly-spaced openings into a continuous underground tunnel of reinforced concrete. These openings are controlled by electrically operated gates through which rock may be deposited on conveyor belts. Grades of rock are blended by proportioning the desired grades through these gates.

At about the mid-point of the tunnel, two transfer conveyors carry the rock out

of the tunnel to a dual conveyor system entering the dry plant. The tunnel conveyor can feed either or both of the transfer belts and the transfer belts, in turn, can feed either or both of the dry plant's conveyors. This permits rock to be removed at any controlled rate from any point in the pile, or from several points at once, resulting in continuous dependable operation and accurate blending.

The old system which the new one replaced, a concrete-bin-type system with reclaiming conveyors, allowed limited storage and blending and less efficient handling of incoming hopper cars. The new facilities prevent delay of railroad equipment and, more important, result in better service to customers by permitting quicker deliveries of more accurately blended phosphate rock.

Ammonia Synthesis Process

THE Casale ammonia synthesis process catalytically unites hydrogen and nitrogen in molecular proportions at an ultimate yield of 97 to 98%, and has been adopted in many manufacturing plants throughout the world for the production of ammonia. The catalytic union of hydrogen and nitrogen takes place at pressures from 600 to 800 atmospheres. If cooling water is available at temperatures under 85° F., this operating pressure permits the production of ammonia in liquid form. The synthesis circuit consists mainly of a catalytic converter, the main heat exchanger, the water-cooled condenser and auxiliary ammonia-cooled condenser, and ammonia separating receivers.

As described in *Heat Engineering* (1952, 27 (2)) a significant feature of this process is the use of an ejector which recirculates the unconverted hydrogen and nitrogen back through the converter. This ejector takes the place of the recirculating com-

pressor used in other ammonia synthesis circuits. The ejector used for recirculating gas is claimed to be more economical than a compressor, giving greater simplification in piping, allowing higher yields due to minimising of leakage, and eliminating oil contamination in the gas stream which is always possible in plants using circulating compressors. Another feature of the construction of the catalytic converter is the use of a concentric heat exchanger located between the catalytic converter wall. The reaction is highly exothermic and the heat liberated during the catalytic reunion of hydrogen and nitrogen to form ammonia is exchanged with the incoming gas stream, raising it to the desired operating temperature before it enters the catalytic reaction zone.

There are said to be some 40 Casale ammonia synthesis plants in operation in the world with a total installed capacity of more than 5,000 tons/day.

Chemical Plant and Equipment at the B.I.F.

MUCH of the plant and equipment shown at the 1952 British Industries Fair at Castle Bromwich, Birmingham, was of direct interest to the chemical industry. In spite of the high pressure at which the engineering industries have been working to fulfil the demands of rearmament and the export drive, the need for continuous innovation and development has not been overlooked and several new and improved products were displayed. As noted in the following paragraphs, outstanding exhibits included a new pneumatic conveying system for dry powders, a submerged combustion unit for concentrating acids, a new industrial mixer, a device for testing welded joints and a new gear unit for mixers and agitators.

The main feature of the refractories displayed by the **Morgan Crucible Co. Ltd.**, was their new refractory, **Morgan M.R.1**, which is rigid at 1,600° C. It is recommended for any position where firebrick is used, particularly where conditions are severe. **Carbinert** impervious graphite was also shown. It is claimed to have an exceptional resistance to corrosion and a high rate of heat transfer, making it particularly suitable for heat exchanger equipment handling corrosive liquids. **Carblox** chemical resisting tiles and cements, which are manufactured by an associate company, **Carblox Ltd.**, provided a third group of exhibits. **Carblox** tiles backed and jointed with cements of the same substance are claimed to be resistant to practically all inorganic and many organic reagents.

In addition to their standard industrial ceramic ware, **Doulton & Co. Ltd.** showed a model of a static pneumatic porous ceramic conveyor system for conveying sand, cement or other dry powders by blowing air through the porous ceramic slabs to move the material down the inclined static conveyor. This has been constructed by the company for further development work.

Most of **Edgar Allen & Co. Ltd.**'s exhibits comprised steel castings and small tools. However, their crushing and grinding machinery as well as cement-making plant were featured.

A double-pedestal, transportable, industrial mixer was shown by **Foster, Yates & Thom Ltd.** The mixer container is a cubic drum mounted diagonally on trunnions and it rotates quite slowly to produce a mixing action which resembles a 'figure of eight' or interweaving motion.

A **Ultrasonoscope** for the detection of flaws in metals, materials, welds, etc., was a new device shown by **Glass Developments Ltd.** This was developed under the auspices of the Ministry of Supply for non-destructive testing of materials. Available commercially, the unit is used to produce a picture on a cathode ray tube screen similar to a radiograph of the speci-

men, but it does the job more quickly and can penetrate up to 20 to 30 ft. of solid steel. It can be used to test any welded joints.

The standard range of **Vacseal** pumps, manufactured by **International Combustion Ltd.**, was represented by a rubber-lined pump, sectionalised to show the method of construction and to demonstrate the special design of impeller common to this type of pump which is claimed to eliminate gland troubles and to make gland sealing water unnecessary.

A working model of a **Swindin** submerged combustion unit for concentrating acid solutions was demonstrated by **Nordac Ltd.** The concentrator units are designed with or without pre-evaporator units to meet the demands of any particular problem. Units handling a variety of liquids have been giving satisfactory service for a number of years and are now in increased demand for economising in the use of sulphuric acid. Existing units concentrate sulphuric acid to 70% H_2SO_4 , but it is expected that future units incorporating high-efficiency acid mist eliminators will concentrate to higher strengths. Complete installations can be supplied for spent pickle regeneration with removal of solids or for straightforward acid concentration.

Introduced about four years ago to meet the demand for a flange-mounted vertical gear with co-axial input and output shafts, the vertically mounted **Strateline** gear unit is particularly suitable for such applications as mixers and agitators of all types for the food preparation and chemical industries. This year, the manufacturers, **Varatio-Strateline Gears Ltd.**, exhibited an entirely new model incorporating an amended coupling increasing efficiency and freedom from wear. These vertically mounted gears are exactly similar to the company's horizontal types, also exhibited, except that lubrication is by an internal pump.

The main feature of the **Aerox Ltd.** stand was a 6 ft. 6 in. aerating tank demonstrating **Porsilex** media. It was equipped with three different grades of **Porsilex** aerators controlled by a special control panel and fed with compressed air.

A wide range of pulverisers, atomisers and dust collectors was shown by **Bramigk & Co. Ltd.** Their **Mikro-Fil** dust collector is used for the handling and recovery of a wide range of dusts and powders as well as for the elimination of atmospheric pollution. Installations for the handling of ultra-fine radioactive dusts can have a combined capacity of more than 125,000 cu.ft./min., and the unit is manufactured with single or multiple filter cylinders of varying diameters and lengths to meet every requirement.

W. P. Butterfield Ltd., manufacturers of complete plant and units of all kinds in mild steel, stainless steel and aluminium, showed a wide range of plant items. In

addition to supplying manufacturing units, they make mild steel and stainless steel road tanks for carrying bulk liquid chemicals.

Precision components in all grades of plastics were shown by **Resinoid & Mica Products Ltd.**, including their **Resoid** and **Micanite** tubes and fabricated parts manufactured from laminated insulating materials. They now have a new and enlarged factory fully equipped with modern plant for compression, transfer and injection mouldings from moulds manufactured in the company's toolroom.

Photographs and descriptive matter were used by the **Thomas W. Ward Ltd.** Group of companies to illustrate their comprehensive activities. This group supplies raw materials, plant, machinery and services for a multiplicity of interests, and their products include caustic pots, acid receivers, stills, vacuum pans, digesters, condensers, evaporators, vacuum dryers, boilers, and high pressure vessels.

On the **Birlec Ltd.** stand, attention was focussed on the **Lectrodryer** range of equipment for dehydration of air (particularly compressed air), other process gases and certain organic liquids.

Among the exhibitors at Olympia, London, was **British Industrial Solvents Ltd.**, who have extended their plant during the past twelve months and consolidated their position as large-scale manufacturers of industrial organic chemicals. In addition to the usual range of solvents, plasticisers and intermediates, four new compounds were included in their exhibits. These were isopropyl, myristate, used in the manufacture of ester wax based cosmetics and ointments; hexylene glycol, used in brake fluids and in cosmetics; β -methyl umbelliferone, an optical bleaching agent; and pentanol-2, a pharmaceutical intermediate.

Chemical plant exhibited by **Quickfit and Quartz Ltd.**, included an 18-in. diameter glass fractionating column, a 200-litre glass flask and an all-glass plant for double distillation of water which are claimed to be the largest pieces of equipment of their type in the world. Also on view were one-twelfth scale models of SO_2 and HCl absorption towers.

The **Microid Atomill** made by **British Jeffrey-Diamond Ltd.** was exhibited by **Griffin & Tatlock Ltd.**, the distributors. This is a new laboratory grinding mill for use in the reduction to powder of a wide variety of friable, crystalline, fibrous, resinous and other materials to products as fine as 300 B.S. mesh.

At Earls Court, the **Tenaplas** method of covering rods and tubes with extruded PVC tubing by a chemical process was demonstrated by **Tenaplas (Sales) Ltd.**, who also showed their polythene tubing which is suitable for plumbing.

Plant and Equipment

Vacuum tray driers

Important advantages are gained by carrying out drying processes under a reduced pressure. At low pressures, the water or solvent in the material evaporates at a low temperature and also the rate of drying is greater than when conducted in air. In consequence of the low temperature, exhaust steam or hot water can be used for heating so that the process is economical. The rapid evaporation at low temperatures is of great importance in drying materials susceptible to injury at high or moderate temperatures and the absence of air in the vacuum drying process is important where materials are liable to oxidation. Dust hazards, objectionable odours and fire and explosion risks are avoided. Vacuum tray driers are used for drying materials such as gland products, pharmaceuticals and food extracts, sensitive chemicals and dyestuffs, explosives and glues, etc., which are susceptible to decomposition at higher temperatures or oxidation and discoloration when dried in the presence of air.

The bodies of the vacuum tray driers supplied by Apex Construction Ltd. are constructed of welded steel—lighter and more compact than older cast-iron ones—and are jacketed top and bottom to prevent condensation and to make all the shelves usable, the bottom jacket acting as a shelf. The jackets and shelves are designed for a working pressure of 50 p.s.i. and the shelf tops are flat and smooth to provide good contact with the trays. Shelves and jackets are baffled to improve the flow of the heating medium. Staggered sight glasses are provided on all models. Trays of various materials are available for the driers. Interior finish on standard models is aluminium; stainless and other metal-clad shelves and jackets are available with metal-sprayed body interiors when required.

There are five standard body sizes only, and standard shelves are fitted into these bodies according to the working area and shelf spacing required. This means that it is possible to meet almost any specifications while at the same time maintaining complete flexibility and very short delivery times.

Heating can be by steam or hot circulated fluid; direct electrically heated models are also available. Fluid circulation systems are supplied which use hot water or oil heated by steam or electricity, thermostatically controlled, and are complete with circulation tanks and motor-driven pump.

These driers with slight modifications are supplied as drier-impregnators for use in an impregnating unit. Cylindrical driers with shelves or heating coils and a laboratory size are also available.

Pneumatic hydraulic control

Accurate automatic control of dampers and heavy valves, such as used in the control of water level and steam pressure in high-pressure steam boilers, can be obtained by means of the *Deltaregulator*. This unit is a pneumatic industrial hydraulic controller containing two separate systems of air and oil which are built into a self-contained unit. The impulse



The *Deltaregulator*, an automatic pneumatic hydraulic control unit.

system works with an air pressure of 2½ in. water gauge, and the oil system amplifies the impulse and provides the power operation. For a stroke of 8 in. a thrust of 650 lb. is obtained, smaller strokes giving correspondingly greater power. The time for the complete stroke of the operating spindle is 50 sec., and the power consumption of the electric motor is 55 W.

Control can be by means of a small bleed line from the regulator, and a change of pressure in the regulator valve of 0.0004 water gauge is sufficient to reverse the movement.

Among many other applications of the *Deltaregulator*, supplied by Thermocontrol Inst. Co. Ltd., the following may be mentioned: draught control, de-superheater temperature regulator, steam pressure reducing, temperature control of processing tanks, and level control of slummy fluids.

Ring-roll mill for sulphur grinding

The difficulties involved in grinding sulphur include the risk of fire or explosion, hardening of the material as a result of the smallest rise in temperature and its tendency to clog hoppers and chutes. Sulphur also generates static electric charges.

The usual method of grinding consists

of first passing the material through a high-speed grinding mill of the pinned-disc type and then through a series of bolting reels or screens, with renewable fine-mesh screening panels. The pinned-disc mill is capable of delivering a reasonably fine powder in one pass. The sulphur receives very little handling during grinding, so that the tendency to clog is minimised. Unfortunately, the fact that the sulphur hardens on the pinned discs means that these must be changed after about four hours' use, otherwise the rotating parts go out of balance and the friction causes a rapid rise in temperature, with a consequent risk of fire. Special care must be taken, also, to prevent metallic foreign bodies from getting into the machinery. These may mean the generation of sparks, as well as damage to the discs.

Hammer mills have been used as an alternative, but these do not produce such a fine powder and have never been as popular as the pinned-disc mill.

A new slow-speed mill, now in commercial operation, is giving satisfactory service. It is the *Rema* ring-roll mill, made by British 'Rema' Manufacturing Co. Ltd. It is intended to work in conjunction with the same firm's British *Rema* multi-disc unit air separator.

The ring-roll mill employs chrome alloy steel grinding elements, which consist of a vertically-disposed grinding ring with three grinding rolls inside. The mill, which has a large throughput capacity, produces a reasonably fine powder. Power consumption is low. A machine handling sulphur at the rate of 1½ tons/hr. can be driven by a 20-h.p. motor. A 50-h.p. motor will drive plant with a feed rate of 10 tons/hr. For smaller factories a 960-r.p.m., 7½-h.p. motor will drive a machine capable of grinding 10 cwt./hr. Sulphur which has been once through a *Rema* mill will have a fineness of about 40% passing 100 B.S.S.

When the mill and *Rema* unit air separator are used together as a standard closed-circuit grinding plant, oversized particles are automatically returned to the mill for further grinding. It is considered more economical not to try to obtain the final product at one pass and the separator is much more selective when there is a wide variation in particle size of the powder.

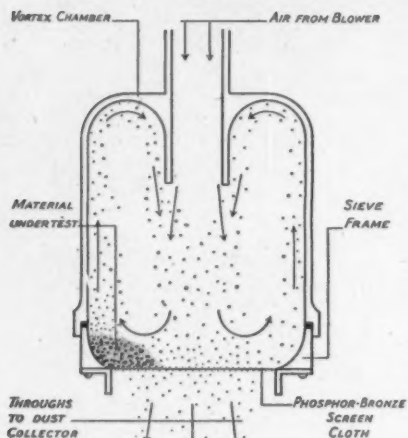
One separator, with three, four or five discs, according to fineness of powder required, will take the place of several of the older bolting reels and screening devices. Consistency of the finished product may be varied by the setting of the separator blades from 90% 100 B.S.S., to 99.8% 200 B.S.S.

The advantages of the ring-roll mill are that there is no rise in temperature during grinding and that only occasional routine cleaning is required. The separator runs at constant speed. Fineness of the powder is determined by the quantity of air circulating, no screens, silks or baffles being required.

Explosion risks are minimised in the new plant by slow running. Inert gases may be used to reduce the risk caused by metallic matter penetrating and causing sparks, but over-feeding of the mill to stifle any tendency to combustion, and the use of explosion-relief doors for the separator, are usually adequate measures.

Powder testing sieve

In contrast to conventional powder-fineness-testing machines involving vibrating, tapping and shaking the powder through a sieve cloth, a new vortex testing sieve employs the unique procedure of urging particles through by means of an

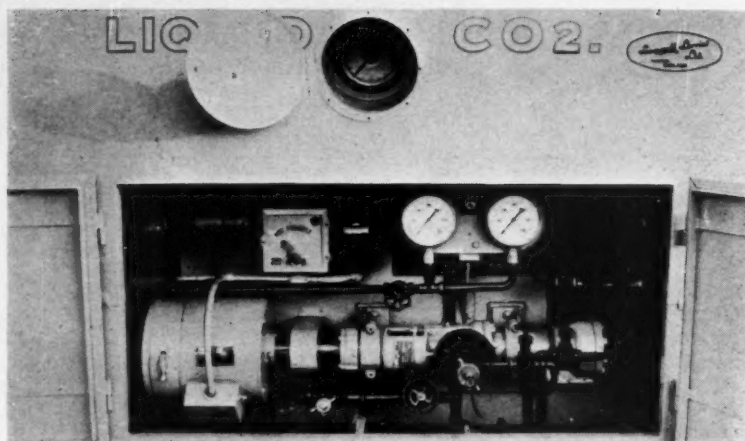


New testing sieve.

air current. It has been developed by Cornwall Mills Ltd. It consists essentially of a vortex chamber fitted with an airtight seal on to a frame holding the sieve cloth. This frame in turn engages with a dust collector bag.

For working, about 6 c.c. of the material to be tested is placed on the sieve cloth held by the frame, so that it can be carried by an air current into the vortex chamber. The sieve frame, with sample, is placed over the dust bag and the vortex chamber then placed over the sieve frame. The electrically driven blower unit is then switched on to perform the actual testing operation. A time switch is fitted, set to a predetermined period. An air current is blown into the vortex chamber, the 'throughs' passing into the dust collector while the residue remains on the sieve cloth. The time switch comes into action to switch off after the set test period. When the blower fan stops the residue is carefully removed and weighed.

The vortex testing sieve is claimed to be very speedy with all sieve finenesses up to 300 mesh B.S.S., a big advance over the older methods of vibrating or tapping. In taking a 10-g. sample of 120-mesh limestone the testing periods are 2 min. with a 120-mesh cloth and 4 min. with a 170-mesh cloth. Samples as coarse as $\frac{1}{8}$ in. can be tested. Phosphor bronze sieve cloths



Pump for bulk handling of liquefied gases installed in the machinery compartment of a road tanker.

are provided with the equipment. Cloths can be changed by the operator in a few minutes. The measurements of the assembled equipment are $64 \times 16 \times 19$ in.; the weight, complete with all accessory sieve frames, is under 45 lb. The standard motor fitted is a fractional horse power, 230 to 250 V., single-phase, A.C. type, although special motors can be provided according to requirements.

Owing to difficulties in the supply of certain constructional parts, the vortex test sieve is not yet on the market, but it is expected to be available this summer.

Liquid-gas pump

A new type of pump devised by Mono Pumps Ltd. is the 1RG40 unit for bulk handling of liquefied gases. It has already been used satisfactorily to deliver and discharge bulk quantities of low-temperature liquid carbon dioxide transported by road tanker vehicles. When discharging this liquefied gas the pressures in the receiving and discharging vessels must be equalised to prevent vaporisation of the liquid. An inherent characteristic of the principle of the Mono pump is the seal between the rotor and the stator, which travels from the suction side of the pump to the discharge end when operating. This principle fulfils a double task in this instance, as not only does it form a most convenient method of transferring the liquid, but the seal also tends to isolate the receiving vessel when the pump is stationary. The fact that the pump can be reversed for both discharging and delivering greatly simplifies layout by eliminating a complicated system of cocks.

Solar furnace

An important new instrument, recently developed for high-temperature research, utilises radiant solar energy and is in operation at Rockhurst College, Kansas City, Missouri. It is described briefly by Dr. W. M. Conn in the *Bulletin of the American Ceramic Society* for May 1951,

p. 163. Although there are no apparent limitations in size, the present and largest unit consists of a solar furnace with an aperture of 120 in. and a focal length of 34 in. which concentrates parallel rays from the sun as an image of the sun, $\frac{3}{8}$ in. in diameter, on to the sample in a small area near the focal point of the parabolic aluminium mirror. Because of energy losses of the sun's rays in passing through the atmosphere, and of reflection and absorption losses, the temperatures attainable are somewhat less than the apparent temperature of the sun ($6,000^{\circ}\text{C}.$). Up to $2,000^{\circ}\text{C}.$ (which can be reached even on slightly hazy days) the temperature can be controlled to within $\pm 1^{\circ}\text{C}.$ The 120-in. mirror (which is supplemented by a 60-in. searchlight mirror for preliminary work) is mounted in an oval frame, firstly so that it can be adjusted about the minor axis of the oval for changes in solar declination and, secondly, so that when driven by an astronomical clock it can, by rotation about the major axis (which is parallel to the earth's axis), track the sun for more than 2-hr. periods without resetting. This furnace is particularly suitable for refractory investigations such as determination of melting points and high-temperature modifications, and it is being used in attempts to extend the temperature scale and in developing new high-temperature materials. The provision of very pure conditions (that is to say without electric or magnetic fields or gases and fumes) in an oxidising atmosphere and the attainment of $2,500^{\circ}\text{C}.$ in a matter of 10 sec. are among its major advantages, but the small area of heating provided is a notable limitation. Work is in hand for making the furnace also usable under neutral or reducing conditions or in a vacuum. (From: *Colonial Geology and Mineral Resources*.)

For further information on new plant and equipment, please complete the coupon on page 330.

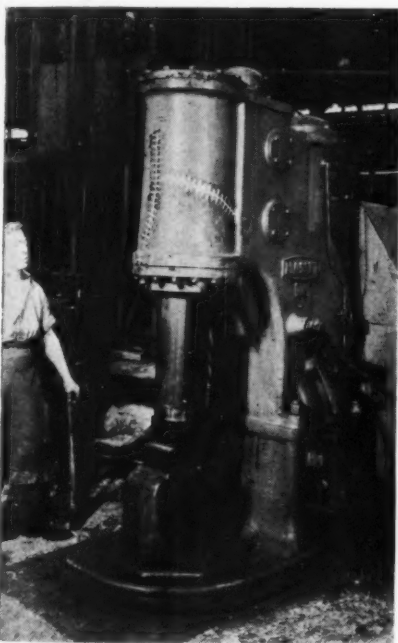
Cold Repair of Castings

THE Metalock process for the cold repair of cracked and fractured castings has recently been introduced into the U.K. by Metalock Ltd. It was originally devised in America in 1935 for use in the Texas oilfields, owing to the danger of fire when welding, and is a method of repair based on different principles.

To effect a repair, the fractured component is clamped to regain alignment if necessary. By means of a jig, lines of blind holes are drilled transversely to the fracture. These pilot holes are then opened out to size, the depth of the holes depending upon the thickness of the parent metal, and the channel of metal in between the holes is removed by means of a hand-operated pneumatic gun tool, the result being a series of holes connected by parallel sections. Into the aperture formed, special keys are driven one after the other in layers, and peened into the parent metal.

The fracture between the locks is then drilled and tapped to receive studs in addition to the keys. After the lacings are inserted the whole repair is pneumatically cold-worked to ensure perfect tightness and rigidity, and the full surface of the repair is then ground flush.

A further application of this process is the Masterlock, which serves as a shock absorber as well as replacing strength into sections of great and concentrated stress.



A typical 'Metalock' repair to a pressure vessel. There was 36½ in. of fracture to the ram cylinder of this power hammer at the works of George Morgan Ltd., Birmingham, and the repair was not only pressure tight, but no rebore was necessary. The job was carried out on site, as is usual, was finished in six days, and it is claimed saved the customer 28-30 weeks delay at about a quarter the cost of a replacement.

It is a block of special high-tensile alloy, around the perimeter of which runs a series of half-round holes. This block is sunk into the cast iron, both surfaces being flush, the half-round holes matching up with opposite numbers already machined in the parent metal. The resultant full holes are then filled with short alloy dowels which are again driven home and cold-worked pneumatically.

To summarise, the main advantages of the Metalock process are claimed to be: (a) dampens and absorbs compression

stresses, spreads tensile strains and provides a good expansion joint for such parts as cylinder liners; (b) distributes the load away from fatigue points; (c) maintains relieved conditions of inherent internal stresses where cracking occurred; (d) provides a low coefficient of expansion against repaired metal; (e) maintains alignment and original surfaces and obviates machining; and (f) work can be done on site with consequent saving in time.

In nearly every case Metalock repairs are guaranteed, all work being carried out by the company's own operators.

Recent publications

Gaseous fuel standards. 'The A.S.T.M. Standards on Gaseous Fuels,' published by the American Society for Testing Materials, has been compiled to collect all of the A.S.T.M. methods of test pertaining to gaseous fuels so as to have all of them together in convenient form for use in industry. The work of this society in this particular materials field is conducted by a committee on gaseous fuels, which in turn operates to a large extent through its subcommittees. The membership of all these committees is composed of a number of representatives of producing and consuming interests in the industry. The contents of this publication include methods of sampling natural gas and measurement of gaseous fuel samples, methods of testing and analysis of natural gas by the volumetric-chemical method, of natural gas and related types of gaseous mixtures by the mass spectrometer, measurement of the water-vapour content of gaseous fuels by measurement of dew-point temperature, and tests for the calorific value of gaseous fuels by the water-flow calorimeter, and for the specific gravity of gaseous fuels. Some of the standards are at present tentative.

Mechanical properties of nickel alloy steels. A new publication summarises the mechanical properties of representative heat-treatable nickel alloy steels. The steels have been selected from British Standard 970, 1947, (wrought steels for use up to 6 in. ruling section for automobile and general engineering purposes) and are divided into two main groups: (1) case-hardening and (2) direct-hardening. In each case are given (a) the specification details for the chemical composition, heat treatment and mechanical properties; (b) representative tests which include the effect of mass; and (c) tempering diagrams (direct-hardening steels only). In comparison with the former edition of this book, which is published by the Mond Nickel Co. Ltd., it is noted that two main modifications have been made, i.e. the effect of size is now taken into account and the value for 0.1% proof

stress has been substituted for the elastic limit. This publication was prepared before conservation of alloying elements became necessary, but it includes some data on some 'economy' steels and on standard nickel alloy steels which can be used as a basis of comparison with other 'economy' steels which may be developed later. When the present situation has passed, many of the standard steels will again be available.

Handbook of Scientific Instruments. The 1951 Directory and Handbook of the Scientific Instrument Manufacturers' Association is a volume of 250 pages. It contains a foreword by Sir Ben Lockspeiser, secretary of the D.S.I.R., and considerable background information on the British scientific instrument industry. Following this is a classified index of products which enables users to find the manufacturers of any industrial, research, medicinal or educational instruments.

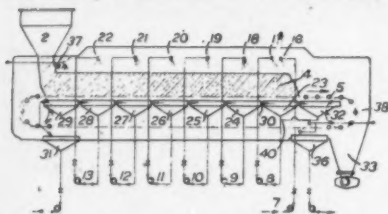
Welded plant. A wide variety of welded and fabricated engineering products manufactured by Davey, Paxman & Co. Ltd., are described in their publication R.1305. The facilities at the Davey Paxman works which were established in Colchester in 1865 are described. The works are well equipped with plate preparation and bending plant, most of it having been introduced to deal with boiler manufacture. There is a press brake of 300 tons capacity which can take work 10 ft. 9 in. long and ½ in. thick and horizontal and a vertical plate rolls. A special machine is available for spinning the ends of boiler flue sections which are heated in a small oil-fired furnace alongside the machine. Rotary shears and nibblers are also provided for cutting curves in light sheets or plates. Metallic arc welding is generally employed for stainless steels. A typical example of an all-welded construction is a double rotary filter. This is fabricated from mild steel and curved sector plates are used whereas a stainless steel filter consists entirely of flat plates. Other welded structures include cylindrical boiler flues, agitator tanks, causticisers, steel sectional boilers, and crankcases.

Chemical Engineering Invention

MONTHLY SUMMARY OF PATENT CLAIMS

Continuous countercurrent extraction

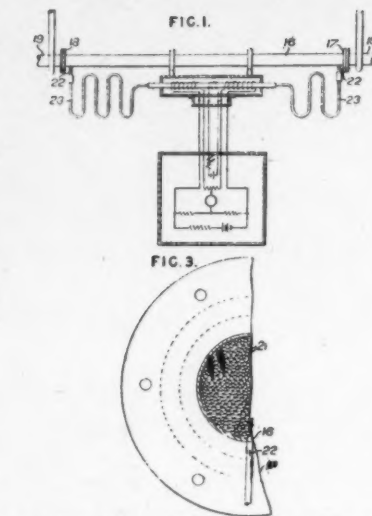
Apparatus for the continuous extraction (countercurrent principle) of soluble matter from solid material comprises an endless openwork conveyor upon which the disintegrated material is fed and beneath which are tanks in which the liquid passing through the material collects, the tanks being connected by overflow means so that liquid extracts of progressively increasing concentration overflow continuously from tank to tank from the discharge to



feed ends of the conveyor, such extracts being produced by recirculation of liquid from and back to each tank through the material of the conveyor. As shown in connection with the extraction of oil from kernels, the ground kernels are fed from a hopper 2 on to a conveyor 5. A pump 7 feeds fresh solvent upon the kernels, which have already been progressively exhausted by treatment with liquid extracts of decreasing oil content, the solvent falling from the sprinklers 16 passing through the bed 4 into a tank 23. The liquid extract so formed is taken up by the pump 8 and discharged through the sprinkler 17 upon the kernels lying above the tank 23, while the liquid extract collecting in tank 23 finally overflows through the pipe 30 into the neighbouring tank 24. In like manner the liquid extracts in tanks 24-29 are passed through the kernels directly above these tanks by means of pumps 9-13 and sprinklers 18-22 respectively. The richest extract overflows from tank 29 into a storage tank 31, from which it passes to a solvent recovery apparatus. Before the exhausted and drained-off kernels are unloaded at 38 into a hopper 33, solvent drippings are collected in a tank 32 and may overflow into the adjacent tank 23 or be introduced directly into the liquid extract circuit as at 40. After unloading, the conveyor is washed with rich, filtered liquid extract from tank 31, which is then collected in a tank 36, and finally passed through fresh kernels at 37.—616,825, J. A. de Smet.

Measuring fluid flow

An arrangement for measuring fluid flow comprises a flowmeter having a sensibly linear response over a range of flow rates, shunted by a laminar flow resistance



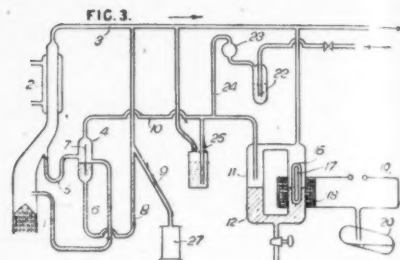
constituted by a large number of passages such that the percentage change in branching ratio with mass flow is less than the percentage deviation from linear response in the flowmeter. As shown in Fig. 1, a flowmeter of the kind described in specification 591,690 and having a linear range of 50 c.c./min. of air or 300 c.c./min. of hydrogen at N.T.P. is adapted by means of a shunt to measure flows up to 6 kg./hr. of hydrogen at N.T.P. The shunt comprises a brass tube 16, 37 in. long and 2 in. internal diameter, coupled to a standard 2-in. pipeline 19 by internally smoothed flanges 17, 18. The passage in the tube 16 is split up into approximately 1,600 similar narrow channels by partitions constituted by sheets 21, Fig. 3, of tinned copper foil, alternate sheets being corrugated and the remainder flat. The flowmeter is connected to the shunt by approximately 3 yds. of capillary tubing 23 of 0.7 mm. bore and by two short brass tubes 22 of $\frac{1}{16}$ in. bore soldered at right angles into the larger tube 16.—617,942, H. Kronberger.

Ruthenium catalysts

Catalysts comprise ruthenium compounds supported on a carrier, e.g. charcoal, silica gel, kieselguhr or alumina. One method of preparation given involves fusing finely divided ruthenium oxide with sodium peroxide in a nickel crucible, pouring the aqueous solution of the resulting melt over activated charcoal, and drying and powdering the resulting charcoal containing ruthenium oxide. The catalysts may also be prepared by methods involving reduction of a compound of ruthenium in the presence of a carrier substance. Several ruthenium compounds are specified.—619,706, E. I. du Pont de Nemours & Co., W. Kirk, R. S. Schreiber and G. M. Whitman.

Testing and distilling liquids

Samples or portions of predetermined volume are removed from a main stream of liquid by diverting the stream to a vessel of volume adequate to hold the portion required, the vessel being provided with (a) an overflow from which the liquid normally returns to the main stream; (b) a conduit leading to a sampling or off-take receiver; and (c) a connection to a source of pressure (gas), the connections being



arranged so that on application of pressure (1) flow from the main stream ceases and (2) the portion or part thereof collected in the vessel is driven over into the collecting receiver. Automatic operation to remove samples at predetermined intervals is provided. The process is described with reference to a distillation process carried out in a column 1 provided with an off-take 3 cooled by condenser 2 so that condensate formed is fed through line 5 to a vessel 4 from which the condensate returns normally through line 6 to the column 1 as reflux. The vessel 4 is provided with a central baffle plate 7, a U-tube 8 leading through line 9 to the sampling receiver 27, and a pipe 10 through which the gaseous pressure agent is supplied. The pipe 10 is connected (a) to a tube 24 through which nitrogen is supplied through a sulphuric acid bubbler 22 and trap 23; (b) to a lute 25 provided with a variable head of liquid which can be varied in height according to the quantity of sample required; and (c) by a bent end portion so as to dip into a U-tube 11 filled with mercury 12 and provided with a glass float 14 containing a soft iron armature 17, the corresponding part of the U-tube being surrounded by a solenoid 18 connected into an electrical circuit 19 closed by tilting a mercury switch 20. On closing the circuit, the solenoid is energised and depresses the float 16, thus causing the mercury to flow up the limb of the U-tube and close the end of pipe 10. The pressurising gas is thus forced to flow into the vessel 4, whereupon flow of condensate through pipe 5 ceases and the sample collected in vessel 4 is evacuated into the receiver 27.—613,938, A. W. Baker and Imperial Chemical Industries Ltd.

World News

GREAT BRITAIN

Stricter control of effluent gases in Scotland

Aluminium works and certain other industrial works in Scotland will, for the first time, have to be registered with the Department of Health for Scotland under the Alkali, etc., Works (Scotland) Order, 1952, which comes into force on July 1.

The order amends the 1906 Alkali, etc., Works Regulation Act to bring up to date the control of 'noxious and offensive' gases from specified types of industrial works. It adds new gases and works, in accordance with modern industrial development, to those already controlled by the Act.

Additional gases and fumes to be included under the terms of the new order are: sulphuric anhydride; sulphurous anhydride, except that arising solely from the combustion of fuel; fumes containing silicon, calcium, aluminium or their compounds; fumes from paraffin oil works containing any sulphur compound; fluorine; volatile organic sulphur compounds.

Copies of the new order can be obtained at H.M. Stationery Office, and any manufacturer who thinks he may have to register his works should get an application form from the Department of Health for Scotland, St. Andrew's House, Edinburgh 1. This should be done without delay, as prior inspection is essential to a first registration.

Chemical engineers' annual dinner

The annual dinner of the Institution of Chemical Engineers took place at the May Fair Hotel, London, on April 25. The guests included Lord Woolton, Lord President of the Council, the presidents of the Society of Chemical Industry, the Institution of Civil Engineers, the Royal Institute of Chemistry, the Institute of Mining and Metallurgy, the Institute of Petroleum, the Institute of Fuel and the Association of British Chemical Manufacturers, the chairmen of the Advisory Council of the Department of Scientific and Industrial Research, the British Chemical Plant Manufacturers' Association and the Chemical Engineering Group of the Society of Chemical Industry, and their ladies.

In giving the toast of the Institution, Lord Woolton referred to the important part that chemical engineering would have to play if Britain was to apply the fruits of research to production, giving as examples of advances, originally made in the country but exploited abroad, the discovery of aniline dyes and of penicillin.

Replying to the toast, the president of the Institution, Sir Harold Hartley, particularly welcomed Lord Woolton as being Chancellor of Manchester University,

which had recently decided to appoint a professor of chemical engineering. The Osborne Reynolds Medal for 1951 was then presented to Major F. A. Freeth, F.R.S., a vice-president of the Institution, for his great contributions to chemical engineering. The toast of the guests was proposed by Mr. F. Fraser Ross, the chairman of the Graduates' and Students' Section, to which Mr. John Rogers, I.C.I. chairman and president of the S.C.I., responded, referring in particular to the high status enjoyed by the chemical engineer in the United States and Canada. At the end of the speeches, Mr. Stanley Robson, in taking over the presidential chain of office, paid tribute to the work of his predecessor, Sir Harold Hartley.

Chemical engineering training

Prof. M. B. Donald has been appointed representative of the Royal Institute of Chemistry on an exploratory committee of the City and Guilds of London Institute which will consider the education and training of chemical engineering technicians.

New adhesion agent

The Road Research Laboratory is now recommending a new adhesion agent, D.S. 2274, for use in surface dressing in wet weather. It replaces cetyl pyridinium bromide, which was previously recommended but is now unobtainable. The new material is at present in adequate supply and has been shown by laboratory tests to be quite as good as the original agent recommended.

The new agent is used to prevent the serious failures which may be caused by rain falling on newly laid surface dressings. Its use means that surface-dressing work need no longer be limited to periods of fine settled weather.

It is applied in a solution of creosote to the interface between the binder and the stone chippings which are scattered on the binder (tar or bitumen) immediately after it has been spread on the surface of the road.

American technical liaison

An agreement has been reached between the New York consulting engineers, R. S. Aries & Associates and Barbet Ltd., of London. The U.S. company deals with a wide range of chemical engineering projects from factory planning to final production schedules. Their technical services are thus now available through Barbet Ltd. to any interested U.K. manufacturers.

Productivity teams

Gas Industry; Plant Maintenance; Conservation of Fuel, Heat and Energy; and Defence (Ammunition) Teams are among those visiting the U.S.A. this year under the auspices of the Anglo-American Council of Productivity.

More members of the Institution of Chemical Engineers

During 1952 membership of the Institution of Chemical Engineers increased by 158 to 2,671, according to the annual report. The number of student members increased most; there were 637, an increase of 67 over the previous year. This can be attributed to a certain extent to the positive encouragement of chemical engineering education given by the Institution. The Council recognised courses in chemical engineering at Bradford Technical College and West Ham Municipal College. Courses were also submitted during the year for examination and approval from the Birmingham College of Technology and the University of Melbourne, Australia. Many individual members of the Institution have assisted in promoting chemical engineering education.

Financially, the Institution had a deficit of £2,339 11s. in the year. This is partly due to the considerable increase in the cost of producing the Institution's technical publications and to the fact that accumulated arrears had been overtaken, publication of the transactions now being up to date. Membership subscriptions were increased at the beginning of 1951. It is expected that a more satisfactory financial position will be reached by the end of the current year.

The Council agrees with the 'Report of the Committee on Chemical Engineering Research' (see our January 1952 issue) and is considering how to aid the implementation of the committee's proposals.

The first meeting of the newly formed Australian Advisory Committee was held in May 1951 and a report was prepared on ways and means of promoting the development of chemical engineering in Australia. A step further in overseas relations was reached this year by the formation of a South African branch (see item under S. Africa in this issue).

Metric system proposed for the drug industry

The principal recommendations of the committee set up by the Association of British Pharmaceutical Industry to study the report on pharmaceutical productivity in the U.S.A. are that from the spring of next year:

(a) Liquid galenicals should be sold by volume instead of by weight.

(b) That solids, liquid galenicals and pharmaceutical chemicals should be sold in metric weights and measures (the liquids by volumes).

Pending the setting up of specifications for a new range of Winchester type bottles to take the new metric volumes conveniently, the Association tentatively suggests that Winchesters should be of such size as conveniently to contain the following volumes: 25, 100, 250 and 500 ml., 1 l. and either 2 or 2½ l. or 2½ l.

Until the new Winchesters can be pro-

duced it is recommended that liquids should be supplied:

			Fl. oz. bottle
25 ml.	in a	..	1
100 "	"	..	4
250 "	"	..	10
500 "	"	..	20
1 l.	"	..	36 or 40
2 or 2½ l.	"	..	80
2½ l.	"	..	90

Other recommendations for higher productivity made by the committee arising from their study of the pharmaceutical productivity report are that individual managements should specialise in manufacture and should try, wherever possible, to reduce the range of products made and of packages. They should also mechanise handling and packaging and, when doing so, give careful consideration to American practice. It is also urged that the import of selected items of processing and packaging equipment should be permitted to a greater extent than at present, as higher output could be obtained for a comparatively small dollar expenditure.

Ramsey Fellowships for chemists

Two Ramsey Memorial Fellowships will be given this year to advanced students of chemistry. Each is valued at £400 p.a., to which may be added a grant of up to £100 for expenses. They will normally be tenable for two years. The funds have been provided by British Celanese Ltd. and the Association of British Chemical Manufacturers, and are being awarded by the Ramsey Memorial Fellowship Trust to commemorate the centenary of the birth of Sir William Ramsey on October 2, 1852.

More honorary fellows of R.I.C.

The election of H.R.H. The Duke of Edinburgh as the first Honorary Fellow of the Royal Institute of Chemistry was reported in the April issue of *CHEMICAL AND PROCESS ENGINEERING*. Six further Honorary Fellows were recently elected. These are Sir Henry H. Dale, Sir Harold Hartley, Lord McGowan, Richard B. Pilcher (former secretary of the R.I.C.), Prof. Arne Tiselius and Sir Henry Tizard. It is not proposed to elect more than one additional Honorary Fellow this year.

New offices

Larger offices have been opened by Barlow-Whitney Ltd., manufacturers of electrically heated equipment, at 2 Dorset Square, London, N.W.1 (telephone: Ambassadors 5485). Their technical sales department will now operate from this address.

HOLLAND

Phthalic anhydride plant

A phthalic anhydride plant has been constructed by the Dutch organisation, Staatsmijnen, in Limburg. One part went into operation in April 1951 and the second in October last. As raw material



MR. STANLEY ROBSON

new president of the Institution of Chemical Engineers. He is an expert on sulphuric acid plants and at one time was a director of the Imperial Smelting Corp'n. He resigned in order to become consultant to the Zinc Corp'n. and several mining and metallurgical companies associated with the Broken Hill mines in Australia. He has been responsible for many developments in metallurgical processes for the extraction of zinc. From 1949-51 Mr. Robson was president of the Society of Chemical Industry. He was born in Sunderland and was educated at Armstrong College, Newcastle-on-Tyne.

Other officers of the Institution of Chemical Engineers are: W. A. Damon, A. G. Grant, R. Edgeworth-Johnstone and Prof. E. C. R. Spooner, vice-presidents; L. O. Newton, hon. secretary; F. A. Greene, hon. treasurer; A. B. Blunsden, G. U. Hopton, E. M. Myers, members of the Council; and Dr. J. M. Pirie, associate member of the Council.

78° naphthalene is used. This is obtained by purification of crude naphthalene from the organisation's coke oven plants. In the production process, the naphthalene is vaporised by means of preheated air and the resultant mixture is passed over a catalyst to convert the naphthalene into phthalic anhydride. By condensing the phthalic anhydride vapours, the product is separated in a solid form. Finally, the crude phthalic anhydride is refined by distillation.

ITALY

Power station uses methane

A new electric power station has started operation at Tavazzano. So far only one generator plant with a capacity of 62,500 kW is in operation. The station, which has a total capacity of 125,000 kW, is the first to be built specially for utilising methane produced in the Padua Valley. It was planned and constructed by the Montecatini Co. in less than two years.

KENYA

Magadi Soda dredge

A new dredge is under construction by the Magadi Soda Co. at its deposits at Lake Magadi, Kenya. The company, which is a subsidiary of Imperial Chemical Industries Ltd., produces approximately 100,000 long tons of natural soda ash and 16,000 tons of salt annually.

SWEDEN

Calcium nitrate project

Preliminary plans have been made for the establishment of a partnership between the Cooperative Union and the State-owned Swedish Shale Oil Co. for the production of calcium nitrate from waste gases at the latter's plant in Kvarntorp. It is estimated that about 18,000 metric tons of nitrogen could be recovered annually if the project, involving a cost of 30,000,000 to 40,000,000 crowns, is completed. The objection has been that imports of calcium nitrate from Norway, which represented about 25% of Sweden's total imports from that country in 1950, would be substantially reduced and that trade relations between the two countries might be impaired.

NORWAY

Paper makers produce synthetic wool and chemicals

The principal Norwegian paper and pulp manufacturing concern, A/S Borregaard, is developing a number of new products, according to a recent statement by the company's managing director, Arne Meidell. He said that the company were already producing artificial wool and that by autumn of this year a new plant would be ready for spinning this wool. Other major extensions are being carried out with a view to greater exploitation of Norway's timber resources. A large new sulphuric acid plant is in the course of construction. In due course the company will be producing enough chlorine and alkali to meet its requirements and it is expected that a number of different chemicals will be developed in conjunction with the chlorine and higher alcohols obtained from the company's aldehyde plant. An acetate department is being developed which will produce a number of products not yet manufactured in Norway, such as cellulose acetate.

Mr. Meidell also stated that A/S Borregaard were to establish an independent research fund with an initial capital of £150,000. In addition, interest-free loans of up to £100,000 are to be given by the company for afforestation in west Norway.

Kirkenes iron mines again in production

The Sydvaranger iron ore mines at Kirkenes, north Norway, resumed production in April. Reconstruction of the mines after war-time destruction has cost £8,750,000. To hasten the work of reconstruction, many of the workers last year surrendered their right to three weeks' holiday.

The Sydvaranger mines are the largest in Norway. Output now is at the rate of 1,000 tons/day and, in the course of this year, it is intended to raise the annual production rate to 500,000 tons. Next year, production will be at the annual rate of 1,000,000 tons.

The whole of this year's production, states one of the mines' directors, Hr. Behrens, has already been sold, mainly to Great Britain, Western Germany and Belgium.

In 1938, Norway's production of iron ore amounted to 1,474,478 tons. By 1945 it had dropped to 106,850 tons. Since the war there has been a steady increase year by year and, in 1951, iron ore output amounted to 437,583 tons. Next year, with the Sydvaranger mines again in full production, total iron ore output should again equal the 1938 figure.

Graphite production to be doubled

Production of graphite at the Skaland Grafitverk mines at Senja, in Troms, north Norway, is to be increased from 3,500 to nearly 8,000 tons a year as from the autumn of this year. At present prices, the export value of the graphite following the production increase will be £200,000 to £250,000 a year. Skaland Grafitverk exports graphite to many countries, including Great Britain, U.S.A., Australia, India, Italy and the Scandinavian countries. Graphite can be used for a number of different purposes. In uranium piles, for instance, graphite can be used as a moderator instead of heavy water.

ISRAEL

Steel industry planned

Plans for the establishment of an iron and steel industry have been submitted to the Israeli Government by the firm of Solel Boneh. The project involves large-scale investments of foreign and domestic capital and is to be undertaken by Koor, Solel Boneh's holding company, in partnership with the Government.

It is planned to exploit the country's scrap iron stocks, the waste accruing from pyrites processed by Fertilisers & Chemicals Ltd., and iron ore deposits in the Negev.

FINLAND

Chemical needs and supplies

Finland's chemical industry depends substantially on imported raw materials, and quotas for these have been included in almost all Finnish trade agreements in the post-war period. Following Korea, prices rose sharply and some materials became very scarce. The country had been importing only its minimum requirements because of exchange problems and was faced with serious shortages. However, the situation has improved; import prices have decreased in some cases, and the continuity of supplies is much better than it was a year ago. Some firms have even managed to stockpile small reserves, a practice formerly not permitted by the licensing authorities. Their attitude has been more lenient since the foreign currency balance has improved.

Only a few commodities are difficult or impossible to obtain. The most important is sulphur and its derivatives. Aluminium sulphate, a chemical used in large quantities by the paper industry, had been imported in recent years almost entirely from the U.K., but this source was virtually cut off in 1951 because of the sulphur shortage, and Sweden, an important pre-war supplier, was unable to furnish the product. However, supplies were available from Western Germany and Belgium. Soda ash, needed by the wood pulp, paper and glass industries, has been scarce. Although there has been a shortage of metallic salts, their importation has been hampered principally by high world market prices. Among the less-used chemicals in short supply are softening and dissolving agents and some organic acids. The U.K. was the leading source for these commodities, but only limited supplies are expected in 1952.

The U.K. has been the principal supplier of chemicals to the Finnish market, but the U.S.S.R. has delivered large quantities of sodium sulphate to the pulp industry, and Western Germany became a leading source

of industrial chemicals and raw materials in 1951. The Netherlands, U.S.A., France, Belgium, Denmark and Sweden are other important suppliers. The outlook for the industry is generally favourable and continued expansion may be expected.

SOUTH AFRICA

Institution of Chemical Engineers' first overseas branch

Some 41 members and eight visitors were present at the inaugural meeting of the S. African branch of the Institution held on March 24 at the University of the Witwatersrand, Johannesburg. Dr. B. Segal opened the meeting and Sir Harold Hartley, then president of the Institution, was present. Sir Harold said it was a privilege to preside at the inauguration of the first overseas branch of the Institution. He paid tribute to the late Dr. William Cullen, who 20 years ago initiated the idea of a S. African branch. Sir Harold then read the petition which had been sent to members resident in S. Africa, 76% of whom had signed it, requesting the formation of a properly constituted S. African branch. The committee elected was: Dr. B. Segal, chairman; M. Salomon, hon. secretary/treasurer; Dr. Taberner, Dr. McLachlan, K. W. Findlay and H. Williams, members of committee.

Nitric acid factory to be built

The Dutch engineering firm of Werkspoor N.V. has received an order from South African Explosives & Chemical Industries Ltd. for the construction of a nitric acid factory at Modderfontein to manufacture explosives for the mining industry and road construction.

AUSTRALIA

Ammonia and urea production

Urea is not made in Australia but is used in the production of urea resins, moulding powders and adhesives. Annual requirements are about 1,200 long tons. The cost of producing ammonia in small Government synthetic plants is too high to permit economic manufacture of urea, and the output is fully used for other important purposes.

A large ammonium sulphate plant is under construction in Tasmania by a private firm. A project for the manufacture of urea in the Commonwealth would depend on the availability of cheaper ammonia; it might also be necessary to consider production of additional quantities of urea for use as fertiliser.

U.K. cement firm's plans

A new cement plant with an initial capacity of 100,000 tons a year is to be built near Fremantle by a British firm, the Rugby Portland Cement Co. Ltd.

The chairman of the company, Mr. Halford Reddish, has confirmed that negotiations for building the plant have been completed with the West Australian Government. Cost would be over

The Leonard Hill Technical Group

Articles published in some of our associated journals in the Leonard Hill Technical Group this month include:

Manufacturing Chemist—Testing Disinfectant Soaps; Practical Possibilities of Ion Exchange; Synthetic Antibiotic Factory; Progress Reports on Analytical Chemistry and Antibiotics.

Petroleum—Cathodic Protection of Buried Pipelines, Part 2; Integrated Phenol Recovery for Low-Temperature Carbonisation Plants.

Atomics—Nuclear Constants for Reactor Studies; Safe Disposal of Contaminated Air from Radiochemical Laboratories.

World Crops—Soilless Cultivation of Plants; The Tilgate Horticultural Station of F. W. Berk & Co. Ltd.

Textile Industries—Alginate Fibres.

Muck - Shifter—The New Jersey Turnpike Super Highway.

Building Digest—First Plastic House; Non-Traditional Methods of Building, Part II, Pre-Cast Concrete.

Pottery and Glass—Packaging for Pottery.

£A2,000,000 and the project would take from two to three years to complete.

A new proprietary company would be formed in western Australia to which, it was proposed, the State Government would advance money against debentures over a term of years.

CANADA

Sulphur from natural gas

The first sulphur-from-waste natural gas obtained in Canada on a commercial scale was recently produced by Shell Oil of Canada at its Jumping Pond plant. Output is expected to be about 9,000 tons of elemental sulphur annually at the present rate of gas production, but will be greater as the market for gas increases.

INDIA

Too much mercury

India's stocks of mercury are estimated at 3,000,000 lb., valued at 10,000,000 rupees, as against the normal annual consumption of less than 300,000 lb. The Mercury Traders Association has suggested to the Indian Government that it would be advantageous to re-export mercury (formerly imported from Spain and Italy) to America, even at prices much lower than those being paid by the U.S. for supplies from Italy and Spain.

A ready market does not seem to be available in the U.S., however, as according to reports, this country now has adequate stocks of mercury, both in national stockpiles and at consumers' plants. Although the U.S. is largely dependent upon imports for home requirements, domestic output has recently been raised, due to the present high price of more than \$200/flask. Estimated U.S. consumption of mercury is about 60,000 flasks annually.

Aluminium sulphate plant

A plant for the production of aluminium sulphate to be used in water purification

processes will go into operation towards the end of the year. It will be the only one of its kind in the country and is expected to cost 1,600,000 rupees.

The Bengal Chemical & Pharmaceutical Works has been entrusted with the construction of the new plant, which is situated at Panihari, near Calcutta. Output is expected to average 30 tons/day of aluminium sulphate.

UNITED STATES

Chemical targets for 1955

The U.S. Defence Production Administration has announced 1955 production capacity targets for ethylene glycol, ethylene oxide and carbon black. These are: ethylene glycol, 850,000,000 lb. (an increase of 327,000,000 over January 1, 1951); ethylene oxide, 969,000,000 (423,000,000); and carbon black, 2,320,000,000 (800,000,000). Of the increased ethylene oxide output, 60,000,000 lb. would go to an acrylonitrile expansion programme which D.P.A. is expected to announce in the near future, 275,000,000 to increase ethylene glycol output and the remainder to increase production of ethers, brake fluids, ethanolamines and rubber polymers.

The U.S. is a major world source of carbon black and exports up to 35% of annual production. World requirements of this material are expected to total 2,464,000,000 lb. p.a. by 1955.

Petrol-from-coal economics

The outlook for making petrol from coal at a cost low enough to be profitable was recently said by the U.S. Secretary of the Interior, Mr. Oscar Chapman, to be very encouraging. He added that the U.S. Government had already set aside \$400,000,000 to encourage the building of plant for making liquid fuels and chemicals by coal hydrogenation.

The Bureau of Mines cost estimates for making petrol from coal have been evaluated by Ebasco Service Inc., as figures given by the National Petroleum Council

had differed greatly with the Bureau's. Based on January 1951 prices, Ebasco estimated the cost at 11 cents/gal. of petrol by the coal hydrogenation process and thought a small profit could be realised when revenues from co-products were taken into account. The National Petroleum Council had previously said that a cost of 41.4 cents/gal. would be more correct, with actual production costs being above 20 cents/gal.

One informal proposal for a synthetic fuel plant to use coal for the production of liquid fuel is still being investigated.

PHILIPPINES

New cement factory

A new cement plant, belonging to the Philippine Portland Cement Co., has gone into production on Guimaras Island, near Iloilo City, at the rate of 2,500 94-lb. bags of cement per day. The company has decided to double the capacity of the plant in a year's time, if demand continues at present levels.

Before the plant went into operation, Philippine cement output was running at the rate of 7,775,000 bags p.a., including 6,000,000 from the Government's Cebu Portland Cement Co., and the remainder from the Rizal Cement Co.

Another plant still in the planning stage is a Cebu subsidiary to be located at San Fernando, La Union. This plant will have a capacity of 2,000,000 bags p.a. and is expected to go into production in about 15 months' time.

International conferences

June 8-12. The 12th annual meeting, Institute of Food Technologists, Grand Rapids, Michigan, U.S.A.

June 9-13. International symposium on 'The Reactivity of Solids,' organised by the Royal Swedish Academy of Engineering Sciences and Chalmers' University of Technology, Gothenburg, Sweden.

June 9-21. General assembly of the International Organisation for Standardisation in collaboration with the American Standards Association, Columbia University, New York, U.S.A. Technical committees meeting include cast iron and cast steel; iron and steel; and petroleum products.

June 14-29. Welding technique conference and exhibition, German Welding Association, Essen, Germany.

June 16-22. The 5th International Congress of the Gas Industry organised by the Union Internationale de l'Industrie du Gaz, Brussels, Belgium.

June 18-20. The 15th Congress of the Organisation for the Advancement of Spectrographic Methods, Paris.

June 23-27. The 50th anniversary meeting, American Society for Testing Materials, New York, U.S.A.

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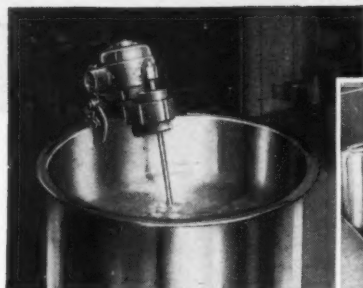
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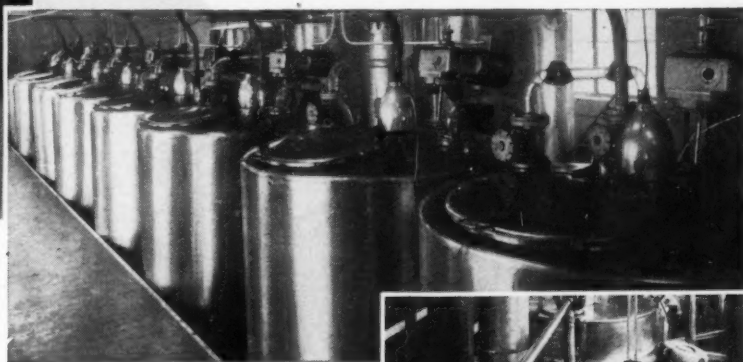
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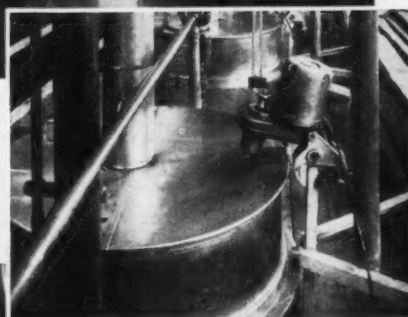
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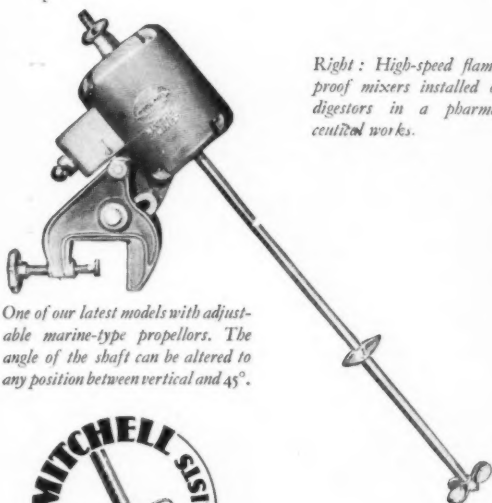
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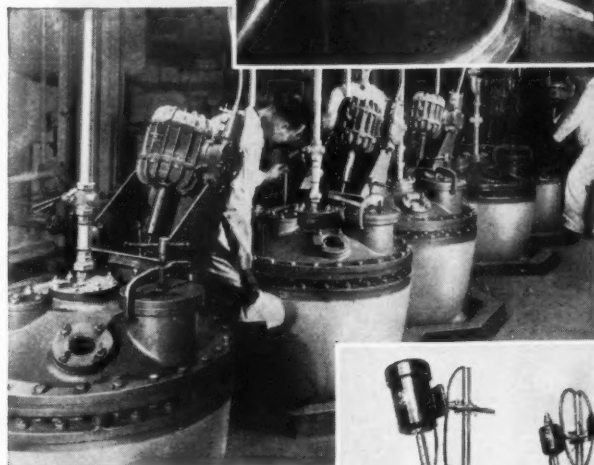
Right: Battery of slow speed WGA Mixers installed on syrup tanks in a leading soft drinks factory.



Right: Battery of medium speed fluid mixers installed on sauce production at a well-known food-stuffs factory.



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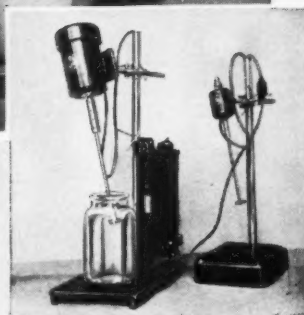


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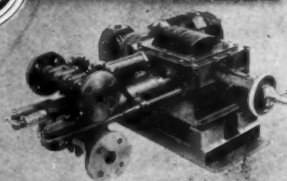
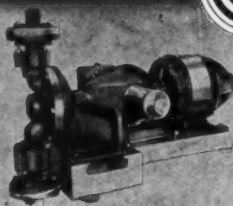
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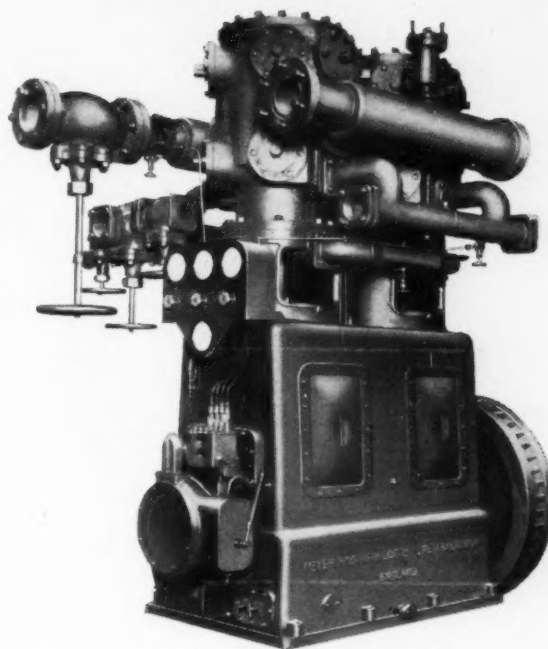
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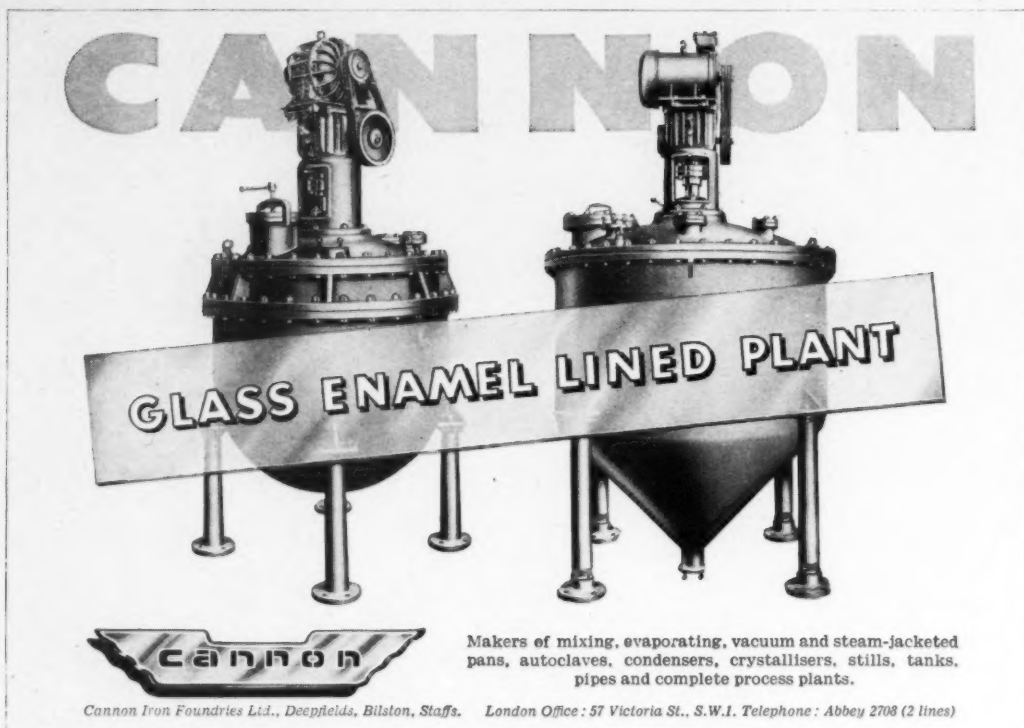
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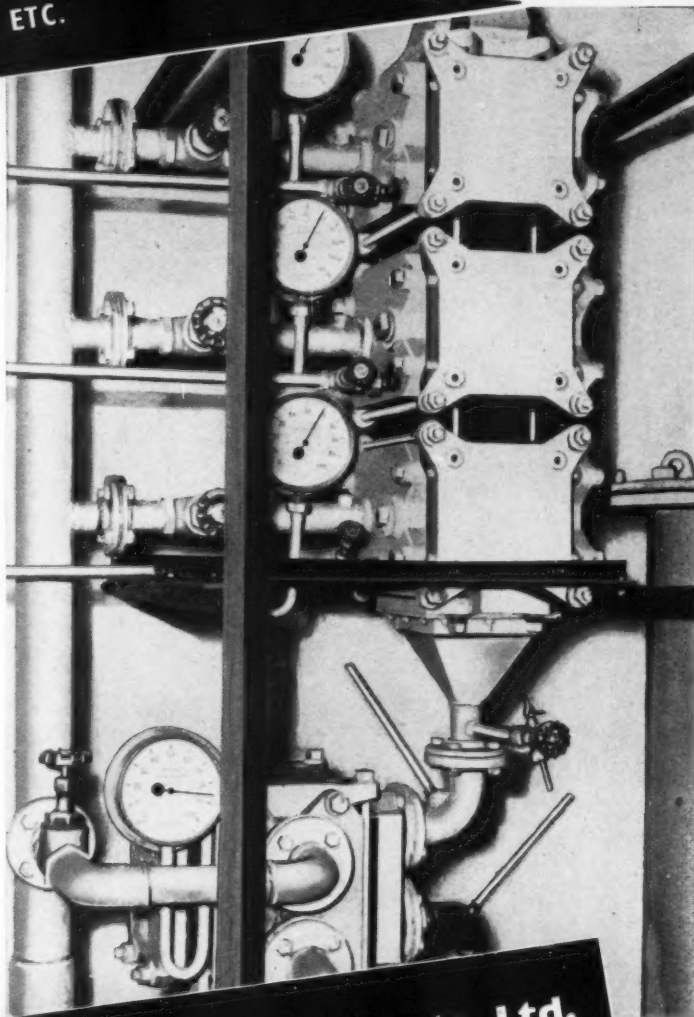
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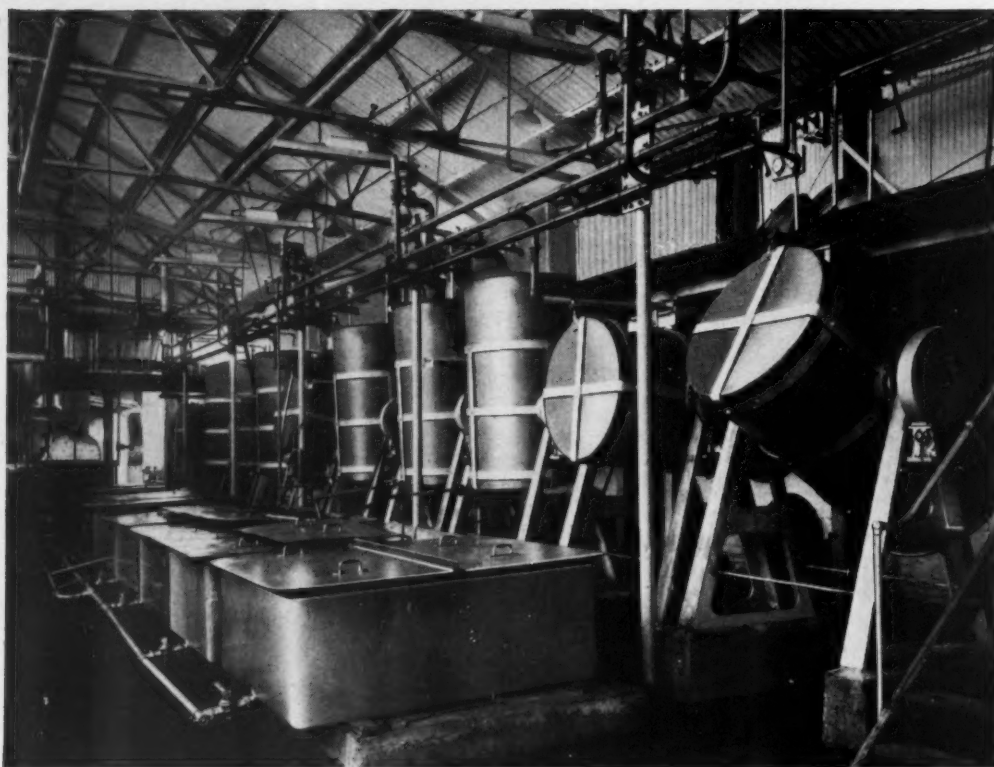
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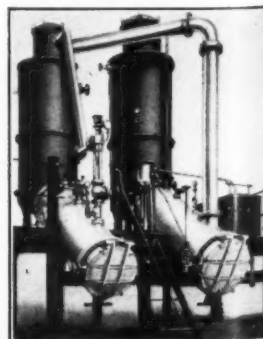
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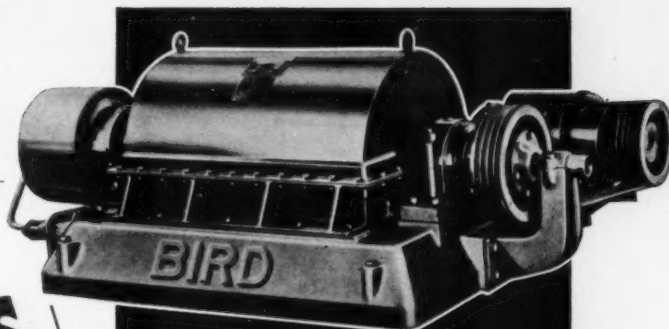
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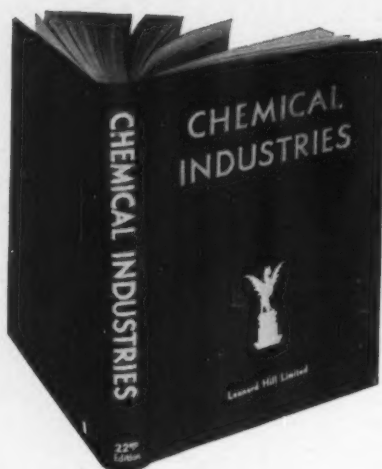
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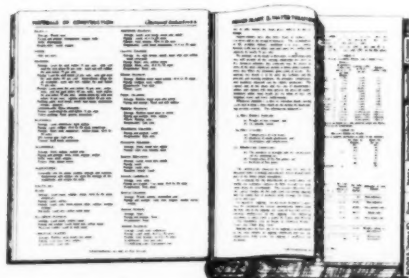
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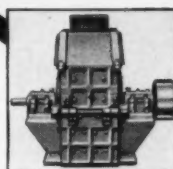
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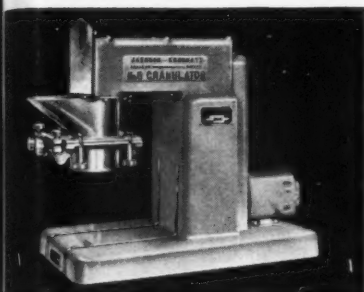
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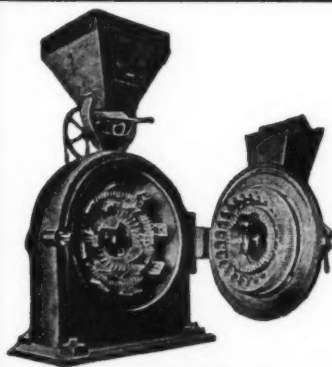
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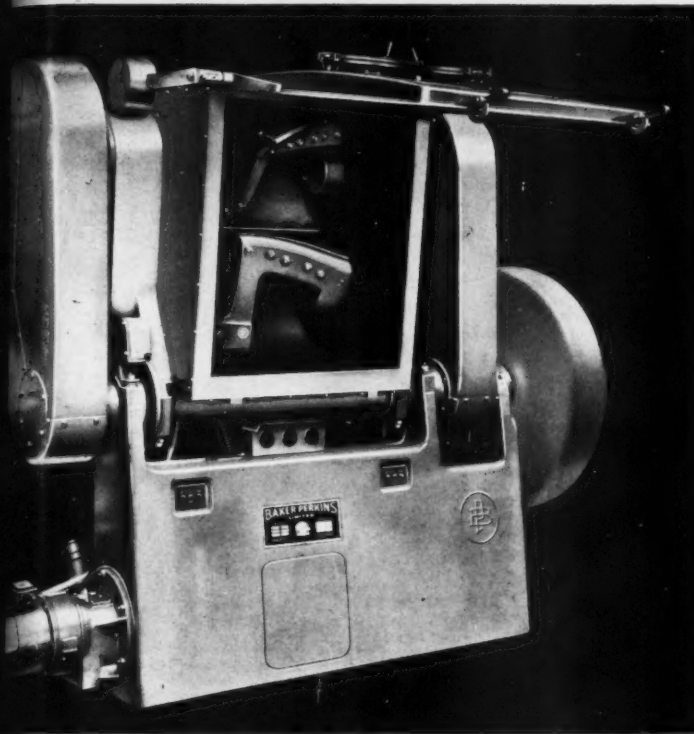
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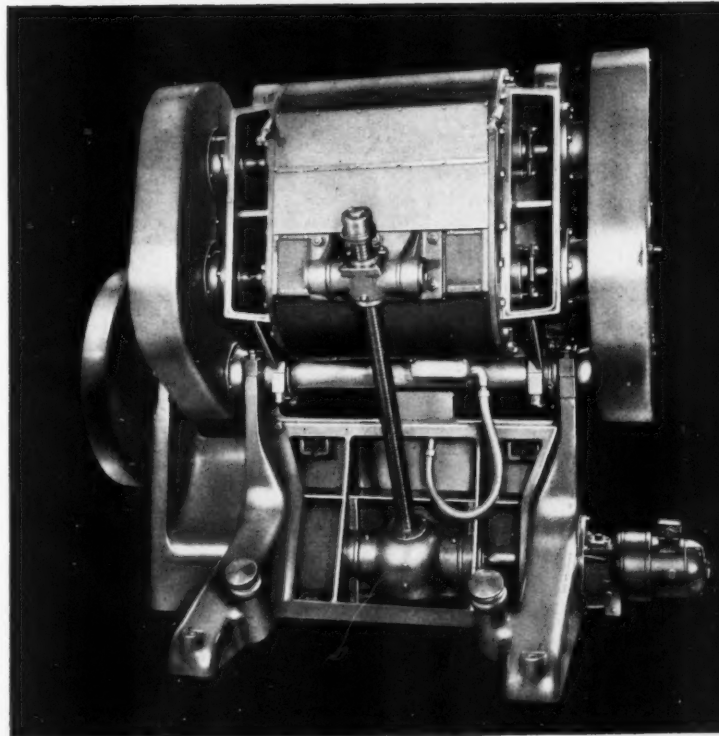
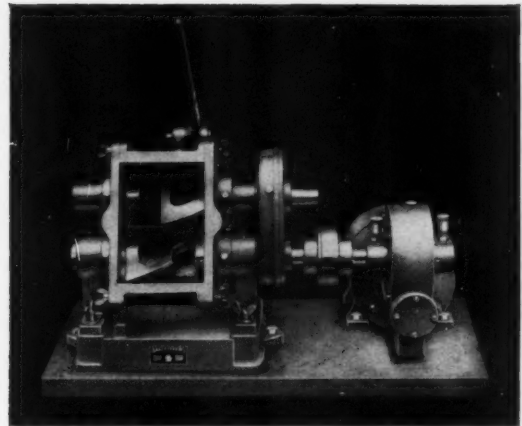
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